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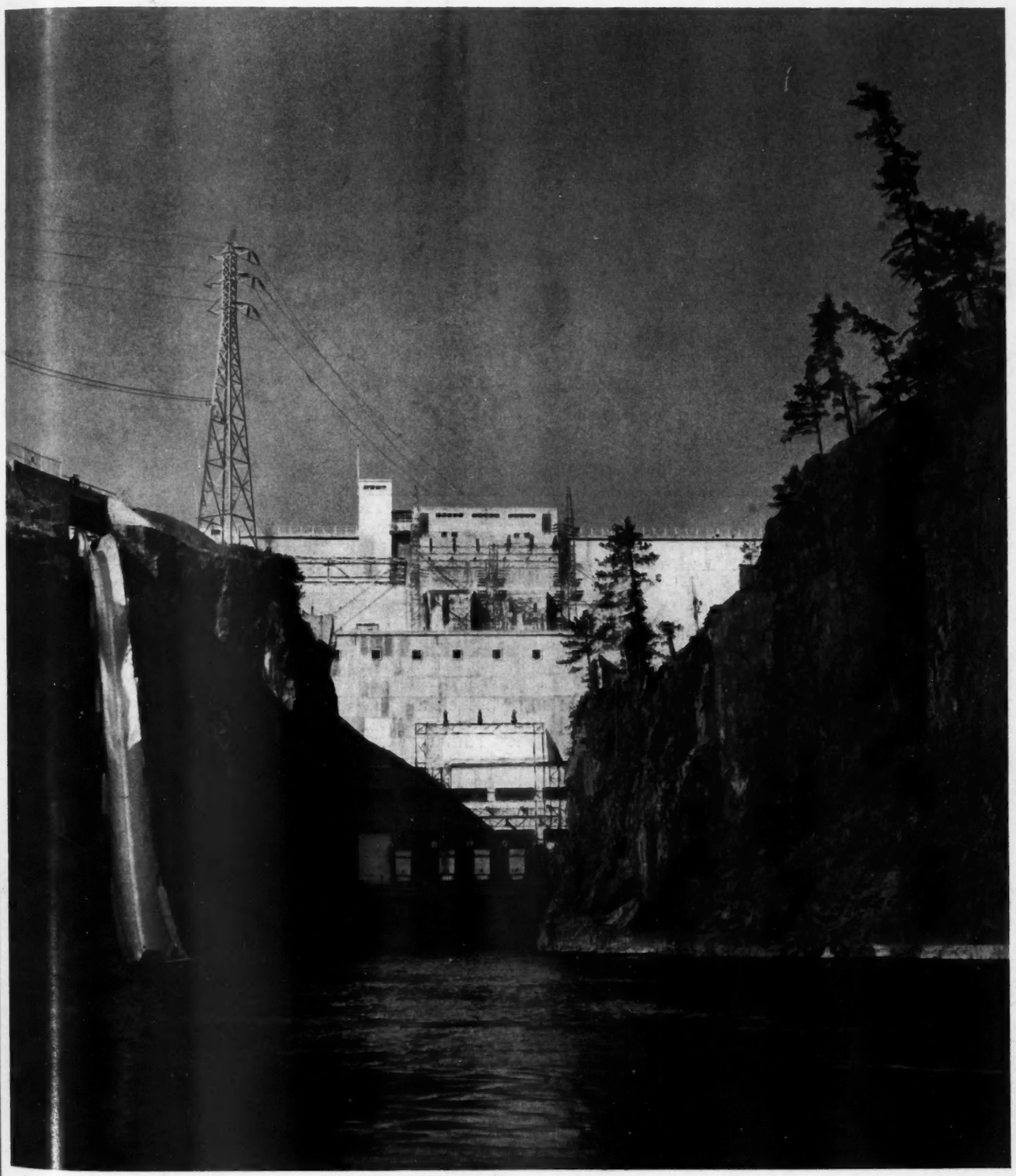

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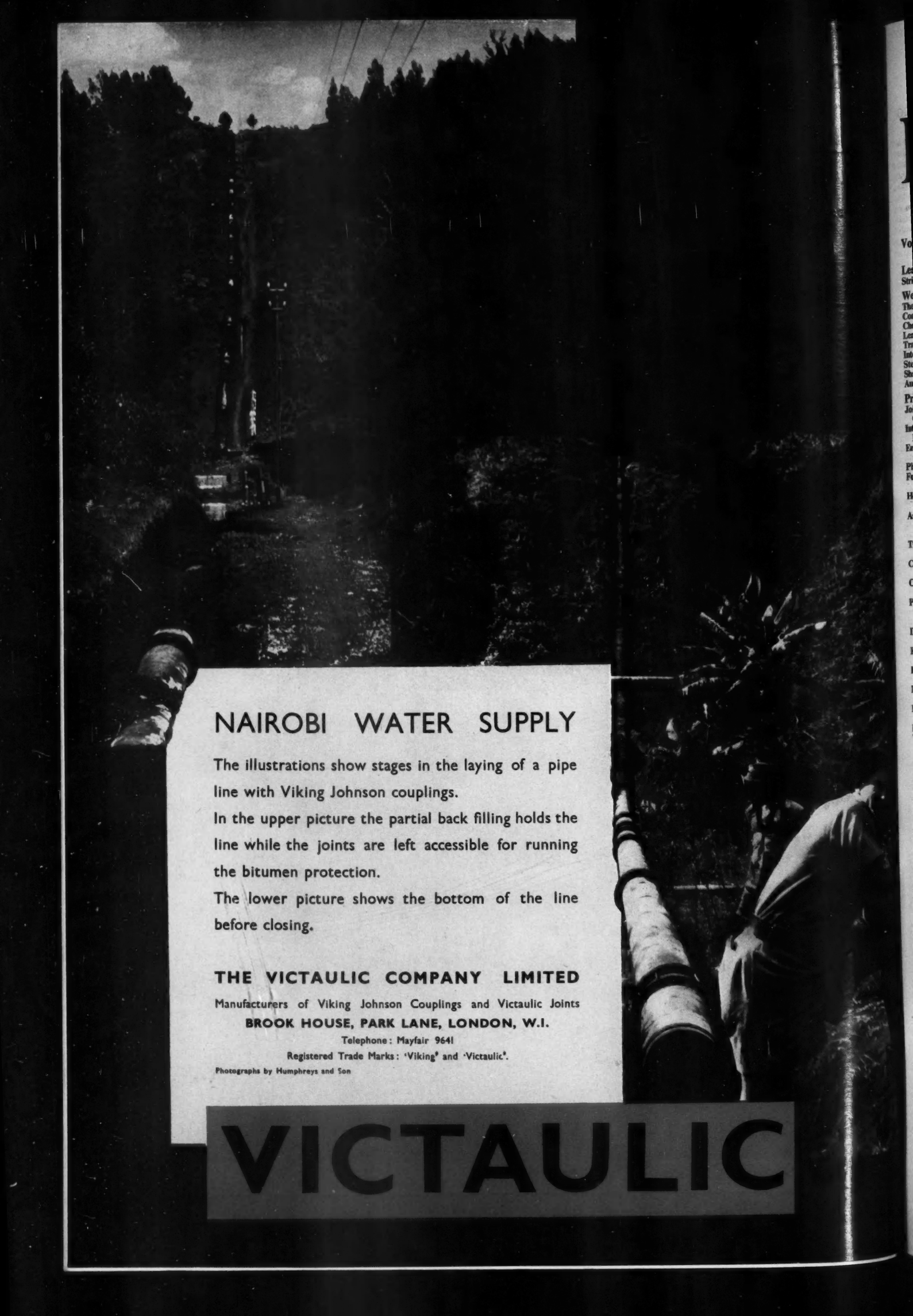

NAIROBI WATER SUPPLY

The illustrations show stages in the laying of a pipe line with Viking Johnson couplings.

In the upper picture the partial back filling holds the line while the joints are left accessible for running the bitumen protection.

The lower picture shows the bottom of the line before closing.

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VICTAULIC

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STRIKES AND SKILLS

FEW industrial conflicts have causes that are plain and can be readily analysed. For the most part—and the rail strike is no exception—the roots go deep into the past and feed on an amalgam of circumstances and traditions that are part and parcel of industrial growth. Few strikes result from the main point at issue: very often a process of simplification goes on, even when the union leaders themselves understand their members' grievances (which is by no means always the case in large unions); or the real grievances are transferred on to something politically viable and likely to appeal to the public conscience.

The Associated Society of Locomotive Engineers and Firemen have made their appeal for public sympathy on the ground that present awards for skill on the railways are inadequate. The catchword is differentials. As *The Times* said in a leading article: "The issue of differentials which they are fighting is one of vital concern to the future industrial vigour of the nation. As many letters in our columns have shown there is a full and sympathetic understanding of their cause." But differentials are not the sole issue in dispute. The A.S.L.E.F. are out to gain pay increases for all their members, some of whom are less skilled than others, and they will admit no classification of engine-crew members. The Transport Commission put forward a proposal for classifying engine crews, and giving increased pay and mileage allowances to those engaged on middle-distance and long-distance work. This the A.S.L.E.F. refused even to discuss. Their demands are for wage increases for all their members, including long-distance or shunting engine crews. The National Union of Railwaymen maintain a similar attitude, and there is no doubt that concession of the A.S.L.E.F.'s demands would immediately bring demands from the N.U.R.

Since the strike began it has been argued in the Press and elsewhere that the withdrawal of essential services cannot be tolerated by the nation, irrespective of the issues at stake; the inference being that no industrial dispute is, or should be, incapable of being settled by discussion, or in the last resort through arbitration. The veteran Liberal, Lord Samuel, publicly advocated that "the old method of settling disputes about working conditions by constant strikes and lockouts, sometimes undertaken lightly but long and bitterly pursued, should be abandoned." But no amount of good intent will banish strikes unless it is clear to all that anyone with a grievance will be heard and equitably treated. Who is to define "equitable treatment," for an individual, a trade union, an industry or the whole nation? There is wide support for higher differentials, but who is to define skill, and what of the technically unskilled workers whose productivity is dependent on long experience, such as the miner, or the docker, who are working under harsh conditions in pursuits vital to the nation's livelihood? When giving the Stamp Memorial Lecture on wages last year, Sir Dennis Robertson, the Cambridge economist, said that opinion on the subject was very diverse and confused, but "tending nevertheless to gravitate towards one or other of two opposite poles." At one extreme are those who regard the existing distribution of income as the result of "a mere dog fight, governed by no principles, since there exists no principle by which it can be governed," and at the other extreme those who "take it for granted that there exists at any time, if only we can discover it . . . a 'proper' wage."

The struggle for differentials is, as Lord Beveridge said recently, "a recurrent theme in the history of wages in Britain," and opposed points of view tend to be held by craft unions on the one hand and industrial unions on the other. His argument—that in an expanding prosperous economy the relative reward of special skill should rise and "that it may be prudent to let it do so, so that men think it worth while to prepare themselves for special tasks or special responsibility"—is admissible, but like Lord Samuel's on strikes, it runs into the rocky shallows of reality. Who is to define what are worthwhile tasks, or what the nation will need ten years hence? More will doubtless be heard about national wages policies. Mr. C. A. Lidbury's plan for a National Wages Board, which bases wage rates on a highly complicated points system of universal application, is likely to receive more attention than it did when first published in 1947. There can, however, be no easy passage for any national wages policy, however fair and deserving of support, since the admission of the principle means the virtual abandonment of hard-won and jealously-guarded positions by every trade union in the country. It might banish strikes on wages issues, but it would also take away much of the point of collective bargaining—the vested interest of trade unionism. This can hardly be expected to happen. It can only be hoped therefore that the area of common ground between employers and the unions will be gradually widened, by increased understanding and goodwill, and that the right to strike, or to lock-out, will be used with more and more discretion and finesse. This would be a worthy aim, to which many people throughout the country could contribute their efforts.

Weekly Survey

Cover Picture. *Near Lake Huron's northern shore in the district of Algoma, Canada, is the George W. Rayner electric generating station of the Hydro-Electric Power Commission of Ontario. Officially opened on June 14, 1950, the 42-MW station is located at the base of the dam, giving an operating head of 215 ft. The cover picture emphasises the steep sides of the gorge of the now-harnessed Mississagi river, but does not show the full 1,000-ft. crest length of the gravity dam. Before construction, the river carried logs from the northern regions; to permit their continued passage, a log chute 890 ft. long by 7 ft. wide (not shown in the picture) has been built to by-pass the dam.*

* * *

THE TANGLE OF TAXATION

The final report of the Royal Commission on Taxation of Profits and Income is a bulky document, too comprehensive for a detailed evaluation in these notes. Therefore, in dealing with only a few points—some of which show rather its weaknesses than its strength—it must be remembered that the report has generally been hailed as competent and thorough. Its acceptance would remove many injustices.

Perhaps the greatest weakness stems from the initial assumption stated in the preamble that there will be no marked change in the purchasing power of money in the United Kingdom. Since in every post-war year the value of the pound has fallen, the unrealistic nature of this assumption is obvious, particularly when the commission admit that if they had been " obliged to assume a persistent decline in the purchasing power of money, even if only a slow one," their examination of the problem of " the inflationary element in profits which are computed without allowance for the decline would have started on a different basis and might have reached a different conclusion." As it is, by their initial assumption, they dodge the burning issue of depreciation at historical cost, which is a serious bar to capital replacement (and consequently efficiency) in some industries, notably shipping. Mr. A. I. Anderson, President of the Chamber of Shipping, drawing attention to the difficulty of replacing ships at four times their pre-war cost on depreciation allowances calculated at historical cost, has said forthrightly that " after years of patient endeavour to convince the authorities by reasoned argument that the British Mercantile Marine cannot hope to survive in adequate strength and efficiency under the existing policy of taxation, we seem to be back where we began."

One recommendation of the commission does eliminate some of the difficulties arising from inflation, but it affects those industries where the effect is on the valuation of stocks, and is small comfort to those like shipping where the effect is on capital assets. The recommendation that stock valuation should be on the " last in, first out method," is, nevertheless, a considerable advance. On some important issues, such as the taxation of company profits, the value of the report is vitiated by the lack of agreement in the Commission. While the majority are in favour of the system of deducting both income tax and profits tax (the latter at a fixed rate) from a company's profits, the minority view that all corporate profits should be subjected (as in the United States and other countries) only to a lower flat-rate profits tax, leaving income tax to be deducted from dividends as personal income, has much to commend it.

* * *

COAL AND STEEL IN EUROPE

The record production achieved by the British iron and steel industry in past months is not unique. On the Continent the rate of expansion has been even faster. According to the latest Quarterly Bulletin of Steel Statistics for Europe, British steel output in 1954 was about 5 per cent. higher than in 1953 and the increase in the first quarter of 1955 was a further 10 per cent., but the corresponding percentages for Europe as a whole were 8 and 16 respectively. This is due partly, no doubt, to the beneficial effects of the Common Market and partly to the fact that European countries had more leeway to make up.

As the third general report on the activities of the Community shows, inter-community trade in steel in 1954 had almost doubled compared with 1952, the year preceding the introduction of the Common Market. This increase is proportionately very much greater than the increase in trade with other countries. Since apart from quantitative expansion the Common Market helped to lessen the influence of the boom on prices, its efficacy during a period of expansion is indisputable. Its effectiveness in recession may be more open to doubt—particularly in view of the undercutting of price schedules which occurred about two years ago. As the report admits, although the Common Market is already a living economic reality there is still room for improvement in its actual operation and for planning in respect of its long-term development. Coal presents one of the most difficult problems for the High Authority. They have to reconcile the interests of producers and workers anxious to obtain support for marginal and uneconomic pits with those of consumers who naturally demand the low prices which can be obtained only from the most efficient production.

* * *

CHEAPNESS IN CARS

The recent decision by Standards to improve the finish and equipment of the Standard Eight saloon and increase the basic price by £20 seems at first to support the popular belief that the British public will not buy cheap cars with simplified equipment. The fact is, however, that the basic conception of the car, with four doors, four speeds, four cylinders, overhead valves and water cooling, brought it into a price category where the crudities of its detail finish were not acceptable. It also possessed other features on which the British public seems unwilling to compromise. They like external access to the luggage locker, winding windows and upholstery which looks like leather, even if it is made of some substitute. The sale of 63,000 Ford Populars has shown that given these things at the right price, they will even accept an old-fashioned appearance, an obsolete suspension system and painted bumpers.

There seems to be a considerable unexploited field for the reduction of production costs in ways which do not incite customer resistance because the customer remains unaware of them, so long as they work satisfactorily. The use of a single hydraulic cylinder to apply two rear brakes on the Austin A 30 is one example. More recent features which have appeared on foreign cars include the use of an inlet manifold cast entirely in the cylinder head on the Fiat 600 and the Peugeot 403; the elimination of valve guides on Ford engines in America and Germany; the hollow-shaft cast-iron crankshaft on the German Ford Taunus 15M; and the use of pressed-steel valve rockers working on ball pivots to eliminate expensive rockers, rocker shafts and attendant fittings on the General Motors Chevrolet and Pontiac V-eight engines in the United States. It is on details such as these that costs can be cut without raising resistance at the point of sale.

Whether the British public would accept a radically simpler car has yet to be demonstrated. The Citroen 2CV has rubber bands for seats, and windows which neither wind nor slide, but it also has a two-cylinder engine, a dynamo without bearings and doors without conventional hinges. New wings can be bought for a few shillings and fitted by the owner with the aid of a wheelbrace inside two minutes. It also happens to be easier to drive, and rides better over rough surfaces than any other small car. It is, in short a different kind of product which cannot be compared with conventional cars simply on the score of interior trim, and it is a pity that a high French factory price, plus the incidence of import duty and purchase tax, have prevented the British public passing a verdict on it. However, there is a school which maintains that to put large numbers of such cars with a very limited performance on our roads would obstruct the traffic stream and add still further to the hazards of a heavily overcrowded road system.

* * *

LEAD AND ZINC

Increasing prosperity in the engineering industry carried demand for lead and zinc to high levels. Consumption of lead in the United Kingdom in 1954 reached 335,500 tons (nearly 10 per cent. higher than in 1953) and consumption of zinc 324,500 tons (about 17 per cent. more). Mr. John Govett, chairman of the Consolidated Zinc Corporation, has pointed out that production of virgin zinc in 1954 by the company's British subsidiary, Imperial Smelting Corporation, the highest in the company's history, was achieved by the development and extension of modern smelting processes which more than offset the planned reduction in output from older plants employing the horizontal retort process.

The largest increases in consumption have been for galvanising and die-casting. To meet the demands of galvanisers and of the brass industry more successfully, Imperial Smelting are now delivering supplies in " palletised " form—a practice already common in the United States and recommended by productivity teams. Increased demand for die-castings has exceeded expectations, and a large amount of additional capacity is being installed to meet the growing requirements of manufacturers of motor-vehicles, refrigerators, washing-machines, etc. Despite increased demand, the industry is by no means complacent about the future. Both lead and zinc have to contend with an increasing number of substitutes, and Consolidated Zinc are giving their fullest support to the work of the Zinc Development Association and the recently formed Lead Development Association. Only the overall increase in demand has concealed the strength of the threat of some of these competitive materials.

* * *

TRAWLER REPLACEMENT

The White Fish Subsidy scheme has greatly stimulated British demand for trawlers and fishing vessels. Prior to the scheme, which came into operation in August, 1953, only seven trawlers of the 140-ft. class were launched on an average each year, but within little more than 12 months of its inauguration, 40 new vessels had been licensed. In his recent annual statement, Mr. W. A. Bennett, chairman of Associated Fisheries, Limited, says that Wyre Trawlers, Limited, a recently acquired subsidiary, will receive grants of £25,000 per ship as well as loans carrying advantageous rates of interest and repayment terms for the major portion of the balance of the cost of building four new Diesel-powered trawlers for fishing near waters. A larger distant-water trawler has also been ordered for Wyre Trawlers and Associated Fisheries have themselves ordered two large modern vessels to replace five old smaller ships. These were ordered from Germany because British yards with full order books could not quote firm (or as low) prices or give delivery in less than three years.

Loss of business to foreign yards is not perhaps serious in present circumstances, but the magnitude of the threat should not be under-estimated. The foreign yards have shown themselves very alive to new technical trends. They have been less embarrassed by the old traditions of steam, and whereas British owners and builders have tended to favour two-cycle direct drive, at about 230 r.p.m., for Diesel-driven middle-water trawlers, the Continental yards have been more willing to experiment with faster-running engines and reduction gearing. They have also pioneered the use of Diesel

electric and "father-and-son" propulsion as well as the variable-pitch propeller designed to solve the dilemma of meeting efficiently the contradictory requirements of ordinary cruising and trawling. The rather complicated "father-and-son" arrangement of a large and small engine has not been free from operating troubles, and Diesel-electric drives are expensive. Both British and Continental yards are working on gas-generators but the general application of these to trawlers is a long way off.

The pace and direction of technical development will continue to be severely limited by such practical considerations as the quality of engineers and the difficulty of finding trawler crews who will stay at sea more than three weeks. Machinery has to be, above all, simple and able to withstand the roughest handling, and since a Diesel engine compares unfavourably with steam in this respect, only a very few Icelandic trawlers (above 140 ft.) are Diesel driven. Even although the economics of trawling could be revolutionised by the employment of large fully-refrigerated vessels capable of staying some months at sea, under present labour conditions their use on any extensive scale is impossible. A most interesting account of the latest developments in fishing-boat design and propulsion is given in *Fishing Boats of the World*, published by Arthur J. Heighway Publications, Limited, London, for the Food and Agricultural Organisation of the United Nations.

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INTERNAL-COMBUSTION ENGINE EXPORTS

British exports of internal-combustion engines experienced a major setback in 1954 when they fell to £25·3 million compared with £35·4 million in 1953. As the British Internal Combustion Engine Manufacturers' Association point out in a recently published paper on the export situation, there was some improvement in 1954: exports rose to £26·5 million and the improvement has continued in 1955. Sales of some types of engine, notably marine auxiliaries, have been very buoyant and in some markets, particularly the Middle East and the Soviet Union, the increases have been particularly large. Since world demand for internal-combustion engines should increase with the continued economic and technical development in backward areas the long-term outlook is reasonably encouraging.

But there are two very strong adverse forces: the growth of local manufacture in the principal markets, and foreign competition. The effects of local manufacture are most apparent in India (where British exports amounted to only £1·9 million in 1954 compared with £4·5 million in 1952), but Spain and Mexico are also important examples of territories, formerly large importers, which now make their own engines. As B.I.C.E.M.A. remark, it is characteristic that measures taken to protect local industries are often unrelated to local demand or the ability of local manufacturers to meet demand. B.I.C.E.M.A. are making a survey of these territories with special reference to the activity of foreign competitors engaging in local manufacture or lending personnel.

The biggest threat from foreign competition comes from Germany. The Japanese are making their weight felt in some Far Eastern markets but their trade has not developed as much as there was reason to fear in 1953, and they are only ninth among the main British competitors in order of export performance. German exports continue to expand, though with somewhat reduced momentum, and reached £13·7 million in 1954 (£1 million more than in 1953). The principal German markets are Europe and Latin America, but strenuous efforts are being made to capture the Middle East and some of the Far Eastern markets. In Brazil, where currency restrictions hamper British internal-combustion engine exports (which fell from £2·1 million in 1952 to £183,000 in 1954), the German trade rose to £1·3 million in 1954—a convincing example of the success of the bilateral policy pursued by Germany in certain markets. The German success is not attributable, however, only to financial shrewdness. Technically, the German products are good and there are some lines of development—notably air-cooling of Diesel engines—in which the progress of German manufacturers has been particularly outstanding. B.I.C.E.M.A. report that one large German manufacturer (presumably Deutz) has recently expanded production by 64 per cent., in spite of quoting 12 months delivery for their air-cooled engines.

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STEAM LOCOMOTIVES REVIVED

Like a *prima donna* the steam locomotive refuses to retire gracefully. In Britain the modernisation plan which would bring in electric and Diesel traction on a large scale has been followed by the railway strike, and now, ironically, by a major improvement in steam locomotive design. Work on the application of Crosti feed-water preheaters was, of course, started several years ago on British Railways, when Mr. R. A. Riddles was responsible for locomotive design. The first of the new engines have now been built, and the design of them is described in an article in this issue.

Although the design is officially described as the Franco-Crosti system, we understand that it is more accurate to speak of the British Railways' single-drum preheater as the Crosti system, and the twin-drum preheater as the Franco-Crosti system. The single-drum arrangement was first used on Italian and German locomotives last year, but the British application appears to be the first time that either arrangement has been employed in a new locomotive, all other uses having been in the form of replacements. Considerable experience has been gained with the twin-drum arrangement. Some 130 have been fitted to locomotives in Germany and Italy, and savings of over 20 per cent. in fuel consumption are reported.

Practicable feed-heating has long been sought by locomotive engineers. In the United States it has been used extensively for the past 35 years, and in Europe 20 years ago there were over 20,000 locomotives so fitted. Originally it was thought that the best method was to extract heat from the flue gases, but in later developments heat was transferred from the exhaust steam in an open or closed heater. In Britain sporadic attempts from the earliest days yielded only one satisfying solution—the widely-used exhaust-steam injector. The Crosti system now to be tried has no moving parts. It avoids the use of a feed pump, the maintenance of which detracted from earlier feed-water heaters, and it extracts heat from both the flue gases and the exhaust steam.

If a fuel saving of about 20 per cent. is obtained the Crosti system will be comparable with the superheater, which did so much for locomotive design nearly 50 years ago. Like the superheater, too, it will permit either increased power from a given locomotive or increased combustion efficiency resulting from the lower fuel rate. At one time the greater first cost and maintenance cost might have mitigated against the Crosti design, but coal availability and cost in Britain to-day may justify it for the years that remain to the steam locomotive.

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SHARING IN PROSPERITY

During recent months, the number of persons at work in civilian undertakings in Great Britain has reached the highest total ever recorded in peace-time and this state of full employment may well be regarded as among the most notable of the Government's achievements. An assurance is given in the Queen's Speech to Parliament that the maintenance of full employment will continue to be the Government's first care.

The Government are convinced that, with a steady expansion of production in industry, commerce and agriculture, an even higher standard of living can be secured for the whole nation. An indication of one means by which the Government hope to secure improvements in industrial relations and a greater share by workpeople in the national prosperity, was given by the Prime Minister, Sir Anthony Eden, in last week's debate on the Address to the Throne. Sir Anthony stated that there was a growing conviction that, if the country was to be fully prosperous and workpeople were to have an increasing share in its ever-rising prosperity, the means must be found, not through nationalisation, but by the workers being given in some form, directly or indirectly, a greater share in the industry in which they were engaged. By whatever name the means adopted might be called, he said, profit-sharing or co-partnership, in some form, had come into British industry to stay.

Schemes giving a share of the profit of a business to its employees have had a long history in Britain and the lack of popularity which appears to have been the lot of many of them seems to have been due largely to the suspicions of the trade unions and to the relative smallness of the sums distributed. The many successful schemes operated in the gas industry were an exception and it is worthy of note that these came to an end with the introduction of nationalisation. The Government's new approach to the question seems a logical development of their principle of a property-owning democracy. No new legislation appears to be in contemplation, but it is certain that the whole matter will be discussed at an early meeting between the Minister of Labour and his National Joint Advisory Council. Discussions with employers' organisations and the Trades Union Congress may well follow. The Ministry of Labour is also likely to resume its collection and publication of information on the subject, which was discontinued some time ago.

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AUTOMATION AND MEN

The conference on automatic factories which the Institution of Production Engineers are holding at Margate this week-end has been preceded by two published surveys of automation. Last week the London Press Exchange produced a booklet on which comment was made in our leading article. This week PEP (Political and Economic Planning) have devoted their June 13 issue of *Planning* to the subject. Their treatment forms an admirable introductory essay for anyone —industrialist, engineer, trade-unionist—who wishes to examine the possibilities and perplexities of automation in a general way and then, perhaps, get down to the detail of that aspect which excites his interest.

The warning is repeated that automation is not likely to spread quickly (it has already arrived in certain industries), but it can involve such fundamental changes that careful forethought must be taken for the managerial, technical and labour issues which will undoubtedly arise. A national issue which PEP stress is the probable shortage of professional and skilled people: "A special difficulty for manufacturers may be the growing shortage of scientists and engineers of all kinds to undertake the vast amount of research, design, and development that automation will need and will make possible. . . . It is extremely doubtful whether there will exist in future years enough newly-trained persons of the required ability and aptitude for such exacting and specialised work. . . . It will become more difficult to obtain promotion in industry except by securing educational qualifications . . . The scarce and highly-qualified engineers will move towards the top of the scale."

In spite of the great efforts that have been made to increase the supply since the war, reactionary influences are still applying a brake. It is high time the hatchet was buried between the arts and the sciences. If there are insufficient recruits for the modern studies, there will not be that degree of prosperity and leisure which is essential for the pursuit of the classical studies. They sink or swim together.

Joint Metallurgical Societies' Meeting in Europe

CONTINUOUS CASTING OF METALS AND ALLOYS

Among the subjects dealt with at the first technical session of the Joint Metallurgical Societies Meeting in Europe, held on the morning of Thursday, June 2, was that of "Continuous Casting," including the continuous and direct casting of aluminium and aluminium-alloy shapes for subsequent working, the continuous casting of copper and copper alloys and the continuous casting of carbon and alloy steels.

The chairman was Professor A. J. Murphy, the joint group leaders, Dr. W. A. Baker and Mr. J. Savage and the American discussion adviser, Mr. J. W. Scott. In his introductory speech the chairman refered to Dr. Junghans, whose name, he said, was bound to crop up frequently in any discussion on continuous casting. Dr. Junghans, who died last September after a long illness, had made his first attempts at continuous casting in 1926 and had taken out his basic patent in 1932

NON-FERROUS METALS

Dr. W. A. Baker, who was the opening speaker, said that, in the non-ferrous field, and for the purpose of this discussion it would probably suffice to refer only to copper and copper alloys and to aluminium alloys, because any reference made to aluminium would apply, in very large measure at all events, to magnesium.

In the light-alloy field the question for a long time had been not whether the newer techniques should or should not be used in preference to the older traditional and conventional methods but whether the continuous or semi-continuous process should be adopted. In the main the semi-continuous process had been preferred universally because of its flexibility and the low cost of the simple equipment used.

Fortunately, the alloys were of relatively low melting-point and it was not a difficult matter to match the supply of suitable metal to the casting rate of the machines, to control the rate of flow of the metal to the moulds, and to find materials of construction which would stand up to the conditions to which they were exposed. The main problems were metallurgical rather than engineering in character, and most of the discussion on the continuous casting of light metals would no doubt range round these metallurgical problems.

In this connection it would be particularly profitable to exchange ideas on the design of moulds and the distribution of cooling water in relation to the problem of avoiding an abrupt change in the condition of cooling as the casting emerged from the short mould and entered the direct water-cooling sprays. Another point which deserved particular attention was a means of controlling the cooling of the billet below the mould in such a way as to minimise the internal stresses which caused so much trouble in casting the stronger alloys.

In the past decade or so there had been a strong trendency to melt high-conductivity copper on a continuous basis, but the bulk of the high-conductivity copper, which represented by far the bulk of the copper that was consumed in the industry, was still made today by a batch process, in which 200 tons or so of copper had to be discharged from a furnace in a matter of a few hours, during which time the condition of the metal was continuously changing. In these circumstances continuous rather than semi-continuous casting was clearly indicated because of the volume of metal, but the fact was that the conventional wire-bar casting was made so easily and cheaply that the improvement in quality which might be expected from these newer processes might easily prove to be too expensive. It seemed, however, that the trend towards the continuous melting of high-purity cathode copper and its continuous discharge from a suitable furnace would inevitably stimulate the continuous casting of high-conductivity copper.

The casting of de-oxidised copper, brass and other copper-alloy billets and slabs was not attended by the problem to which reference had been made, but again the improvement in metallurgical quality which might be expected from the use of a continuous or semi-continuous process did not compare with that which was realised in the case of the strong light alloys.

The choice between continuous casting and semi-continuous processes on the one hand and conventional ingot-casting processes on the other was, therefore, dictated primarily by economic considerations, which, of course, depend very strongly on the output required in a given material of a given cast section.

In a few plants in this country and in more numerous plants in America, where brasses were melted and cast on a large enough scale, continuous processes of the Junghans-Rossi type had been used extensively, but it was probably fair to say that, in the main, such a process was too inflexible for general use in most of the plants in this country.

TECHNIQUES FOR STEELS

Mr. J. Savage said that there were, in Great Britain, three continuous casting plants operating with steel. One was at the Low Moor Alloy Steelworks Limited, and was the company's own development. The second was William Jessop's in Sheffield, this being a joint development by a group of companies together with the British Iron and Steel Research Association. The third plant was at the Barrow Steel Works; it was a Rossi plant, and it was being further developed by the Barrow Steel Works in conjunction with United Steel Companies Limited. The first two plants have concentrated on the casting of special steels, while the Barrow plant had been mainly concerned with the production of 2-in. square carbon-steel sections. In addition to these experimental production plants, the British Iron and Steel Research Association were just completing a rather large plant in their Sheffield laboratory for research purposes.

The range of application of continuous casting to steel was largely governed by the relatively-low casting rate on existing plant and the necessity to cast in a reasonably short time. It was only when these two factors were in balance that continuous casting could seriously be considered as a practical proposition. It was hardly possible to generalise on the question of whether or not continuous casting was likely to be practicable or economical, and every case must be considered separately.

In the steel industry large cross-sections had not been considered very seriously, for a main object in continuous casting was the by-passing of the heavy rolling mill.

Broadly speaking, the application appeared to be limited at present to the output from high-frequency and electric-arc furnaces, while the possibilities for complete continuous casting in the case of the output from Bessemer furnaces were also becoming apparent.

In continuous casting the control of the flow of liquid steel from the ladle must be far more precise than was the case in conventional casting. The rate of input of metal to the moulds must be in balance with the rate of extraction, and only relatively small changes of the rate of input could be permitted if the level of steel in the mould were to remain sensibly constant. Where the input rate was allowed to vary, facilities must be provided for varying the extraction rate of the billets. To date this matching has been manual, although many methods for automatic control had been proposed.

The many types of mould which had been proposed and tried for the continuous casting of steel were far more complex than those seemingly employed in non-ferrous metal casting. It had been a common experience with steel that there was always the danger of rupture of the billet skin in the mould, this skin being very thin and weak and easily broken when subject to tensile forces. The mould systems adopted, however, counteracted this difficulty to some extent.

It had been suggested that the heat transfer through the mould could be controlled in one way or another. His own belief was that within broad limits, the average heat flow from the mould was very little influenced by the mould thickness, the mould materials commonly used, the velocity of the cooling water or whether fixed or movable moulds were used. There seemed to be no experimental evidence available to refute the view held at present that the velocity of the billet withdrawal had by far the greatest effect on the heat transfer from the mould. It had also been stated that the rate of solidification in the case of a continuous-casting mould was greater than that obtained in conventional casting. From the work carried out at B.I.S.R.A., the two rates appeared to be about the same.

Turning to metallurgical problems, it had been a common experience with steel to find some central unsoundness in the as-cast products. In squares and rounds, the central unsoundness was essentially axial. It was for this reason that oval castings had been made by several investigators. He thought that it was also agreed that, provided adequate hot working were applied, this central unsoundness disappeared during rolling or forging. The as-cast surface quality was also important, and it would be interesting to have views on whether continuously-cast steel were better or worse in this respect than were conventional ingots.

With non-ferrous metals it appeared that the quality of the as-cast product was the over-riding factor. With steel, on the other hand, it was the reduction of capital and running costs that provided the greatest attraction of continuous casting, but the full potential had not yet been realised in the present largely experimental stage.

ECONOMIC FACTORS

During the subsequent discussion the point was made that European countries were ahead of the United States in the industrial application of continuous casting and the opinion was expressed that economic factors might be mainly responsible for this. Other opinions on the general subject of costs were that while no one yet had had sufficient experience of the continuous casting of steel to give a definite opinion, the savings to be realised on billets were likely to be substantial. It was also stated that when the process was employed for producing aluminium ingots for subsequent high-speed rolling appreciable reductions in labour costs had been obtained.

Some reference was made to a horizontal type of continuous casting machine, termed the Hunter-Douglas equipment, and it was considered that, for the production of strip, this might have a better future in the United States than the vertical type Junghaus-Rossi machine. One of the engineering problems connected with vertical-type machines was fitting the equipment into existing steelworks. The machines often needed a greater height than was usually available.

Whereas the aim in the steel and the brass and copper-alloy fields was not to cast billets of large cross-sectional area, in the sphere of aluminium alloys the sizes of the ingots produced by continuous or semi-continuous methods were increasing because the aluminium alloys were extending into fields in which much larger pieces of metal were required. When high-strength aluminium-alloy ingots of really large cross-sectional area were being poured the casting speed became very low, of the order of 1 in. per minute or even less. In this country, 20-in. diameter aluminium-alloy billets were in common production by the continuous or semi-continuous processes.

HONOURS LIST

Many engineers, industrialists and scientists are among those whose names are contained in the Birthday Honours List, published on June 9. Included among them are those mentioned below.

Baron

Sir Geoffrey Heyworth, chairman, Unilever, Ltd.

Baronet

Sir George Horatio Nelson, chairman and managing director, English Electric Co., Ltd.

Knights Bachelor

Harold Bishop, C.B.E., director of technical services, British Broadcasting Corporation; John C. Denholm, C.B.E., President, Chamber of Shipping of the United Kingdom; Albert W. Grant, C.B.E., chairman, Engineering and Allied Employers' West of England Association; Robert M. Shone, C.B.E., executive member, Iron and Steel Board; and Hugh E. Watts, C.B., M.B.E., G.M., lately H.M. chief inspector of factories, Home Office.

Imperial Service Order

Rowley T. North, principal, Ministry of Supply, Upper Warlingham, Surrey; and Ernest Waldron, M.B.E., acting superintending electrical engineer, Admiralty.

Order of the Bath

C.B. Engineer Rear-Admiral John E. Cooke; and George W. H. Gardner, C.B.E., director-general of technical development (air), Ministry of Supply.

Order of Saint Michael and Saint George

C.M.G. Harold G. Conde, chairman, Electricity Commission, New South Wales; J. R. Dridan, engineer-in-chief, Engineering and Water Supply Department, South Australia; R. P. Errington, chairman, Aden Port Trust; Lieut.-Com. James Jolly, C.B.E., R.D., R.N.R. (retd.), Director of Marine, Hong Kong; and Humphrey A. W. Morrice. irrigation adviser and director of irrigation, Sudan Government.

Order of the British Empire

K.B.E. Sir George Mowlem Burt, President, Federation of Civil Engineering Contractors; Dr. Alexander Fleck, chairman, Imperial Chemical Industries Ltd., for services to the Ministry of Fuel and Power; and Sir Harold Spencer Jones, M.B.E., Astronomer Royal.

C.B.E. E. M. Amphlett, M.C., member, National Advisory Council on the Employment of the Disabled; William B. Brown, divisional inspector of mines, East Midland Division, Ministry of Fuel and Power; Edwin Butler, senior engineering inspector, Welsh Office, Ministry of Housing and Local Government; Albert E. Childs, director of chemical defence research and development, Ministry of Supply; Philip A. T. Chrimes, chairman, Singapore Harbour Board; Major Cecil R. Dibben, O.B.E., chairman, Midland Regional Board for Industry; John V. Dunworth, head of reactor physics division, Atomic Energy Research Department, Harwell; Clare H. Dutton, vice-chairman, Rotax, Ltd., London; William Fairley, chief civil engineer, Office of the Crown Agents for Oversea Governments and Administrations; Geoffrey E. Foxwell, consulting fuel technologist; Richard W. L. Gawn, O.B.E., assistant director of naval construction, and superintendent, Admiralty Experimental Works, Haslar; Gordon Gibson, chief mechanical engineer, East African Railways and Harbours; Reginald G. Gosling, chairman, Welwyn Garden City and Hatfield New Town Development Corporations; Ernest E. Hall, assistant secretary, Ministry of Supply; Lex H. Hornsby, chief information officer, Ministry of Labour and National Service; George H. Houlden, M.B.E., managing director, shipbuilding division, Vickers-Armstrongs Ltd.; Raymond L. Lawson, deputy director of armament supply, Admiralty; Charles E. Lucette, M.B.E., manager and secretary, Manchester Ship Canal Co.; Reginald W. Lunn, technical director, Leyland and Birmingham Rubber Co., Ltd.; Malcolm S. Mainland, general manager, Iraq fields and pipeline, Iraq Petroleum Co., Ltd.; Cecil G. Mant, deputy director general of works, Ministry of Works; Charles G. M. New, for services to the electricity industry; David D. Pratt, O.B.E., director, Chemical Research Laboratory, Department of Scientific and Industrial Research; Harold L. Raybould, controller of supplies, Ministry of Works; Harold P. R. Scott, joint managing director, Summersons Foundries Ltd., Darlington; Henry E. Steel, chief ship surveyor, Ministry of Transport and Civil Aviation; Frederick N. Sutherland, general manager, Marconi's Wireless Telegraph Co., Ltd.; Robert E. Swift, director of aeronautical inspection, Ministry of Supply; Humphrey G. Taylor, for services to the chain and chain-cable industry; Professor James L. Thomson, Mechanical Engineering Department, Royal Military College of Science, Shrivenham; John N. Toothill, general manager, Ferranti Ltd., Edinburgh; and Percy B. Walker, deputy chief scientific officer, Royal Aircraft Establishment, Ministry of Supply.

O.B.E. Lieut-Colonel (temporary Colonel) Arthur T. Abate, R.E.M.E.; George L. Ackers, chief sanitary engineer, Ministry of Works; William A. M. Allan, divisional engineer, main drainage division, London County Council; Reginald V. Atkinson, works director, Gloster Aircraft Co., Ltd., Gloucester; Herbert L. Beards, assistant scientific adviser, Air Ministry; Donald A. de C. Bellamy, senior engineer, Ministry of Transport and Civil Aviation; William F. Bennett, senior engineer, Ministry of Finance, Northern Ireland; Jack W. G. Bird, M.B.E., chief engineer, South Wales Electricity Board; Ernest S. Blake, M.B.E., vice-chairman, Eastern Regional Board for Industry; James Courtney, chief engineer, Ulster Transport Authority; Lieut.-Colonel Stanford E. Doig, R.E.M.E.; Robert W. Fair, deputy director of patents, Ministry of Supply; J. D'A. Glanville, deputy chief engineer, industrial group, United Kingdom Atomic Energy Authority; Stanley B. Hamilton, principal scientific officer, Building Research Station; Percy J. Hawkins, director of armament supply, Naval Headquarters, India; Leslie B. Hobgen, superintending mechanical and electrical engineer, grade II, Air Ministry; Sidney A. Horstmann, M.B.E., lately managing director, Horstmann, Ltd., Bath; Neville D. Hyam, assistant director of navy contracts, Admiralty; Dennis A. Lamb, general manager, British Overseas Fairs, Ltd.; Robert E. L. Lovell, technical director, Vosper Ltd., Portsmouth; J. B. McNee, director and general manager of engine works, Barclay, Curle & Co., Ltd., Glasgow; David S. Morrison, harbour engineer, Bahamas; James R. F. Moss, constructor, Naval Construction Department, Admiralty; Lionel A. Payne, director and manager, Cooke, Troughton and Simms, Ltd., York; Arthur A. Peachey, assistant director of contracts, Ministry of Supply; Norman F. Richards, director of public works, Nyasaland; Charles E. Richardson, chief executive engineer, Ministry of Works; Elwyn Roberts, senior principal scientific officer, Explosives Research and Development Establishment, Ministry of Supply; Cyril H. Smith, Director of Public Works, Bermuda; Philip H. Spagnoletti, director and general manager, Kolster-Brandes, Ltd., Sidcup, Kent; Albert G. Tapster, superintending examiner, Patent Office; Connolly T. Wilson, managing director, T. Wilson and Son, Ltd., Northampton; and Reginald A. Wright, works manager, Skefko Ball Bearing Co., Ltd., Luton.

M.B.E. James D. Addison, chief mechanical and electrical engineer to the State of Kuwait; Eli Ayland, works manager, engineering division, John Curran, Ltd., Cardiff; Fred W. Bateman, director, Morton Engineering Services, Ltd., Croydon; Ralph Beal, chief marine superintendent, William Cory and Son, Ltd.; William G. Bennett, works manager, Climax Rock Drill and Engineering Works Ltd., Redruth, Cornwall; John M. Boyd, chief switch designer, Electric Construction Co., Ltd., Wolverhampton; Stuart H. W. Boyns, station engineer, Brentford Works, North Thames Gas Board; Cecil R. Brewer, chief draughtsman, Royal Aircraft Establishment; Hugh Brown, engineering chief draughtsman, Harland and Wolff, Ltd., Belfast; Herbert G. Cheel, general manager, General Electric Co., Ltd., Wembley; Harry Cheetham, chief assistant engineer, Trent River Board; Harold W. Cox, electrical engineer, Electrical and Musical Industries Engineering Development Ltd., Hayes, Middlesex; Kemp Day, leading draughtsman, John I. Thornycroft & Co., Ltd., Southampton; Horace D. McD. Ellis, engineer, designs department, British Broadcasting Corporation; William K. Forsyth, chief stations engineer, British Overseas Airways Corporation; Charles Foster, mechanical engineer, Powers Samas Accounting Machines, Ltd., Croydon; John W. E. Gardner, chief new development and process engineer, D. Napier and Son, Ltd., Liverpool; Herbert P. Hale, senior experimental officer, Low Temperature Research Station, Department of Scientific and Industrial Research; Colton R. Hinds, locomotive works manager, North Eastern Region, British Railways; James Hutton, Albion Motors Ltd., Glasgow; Walter Jones, recently assistant manager, plate glassmaking department, Pilkington Brothers, Ltd., St. Helens; Willoughby F. Kelly, experimental officer, Aeroplane and Armament Experimental Establishment, Ministry of Supply; James E. Lambert, senior assistant engineer, North Eastern Electricity Board; John Paterson, works manager, Winsor Engineering Co., Ltd., Glasgow; Frank S. Salter, chief designer, hydraulic department, Loewy Engineering Co., Ltd., Poole; William L. Simpson, chief works engineer, Newey Brothers, Ltd., Birmingham; William A. Smithdale, recentlyse nior shop superintendent, Rolls-Royce, Ltd., Derby; William C. Styan, engineer-designer, Vickers-Armstrongs Ltd., Crayford, Kent; Charles F. Sutton, senior experimental officer, Air Ministry; George H. Todd, shipyard manager, Hawthorn Leslie (Shipbuilders), Ltd., Hebburn-on-Tyne, County Durham; and William F. Young, director, Resistance Welders, Ltd., Inverness.

International Internal-Combustion Engine Congress (*continued from page* 720)

DIESEL ENGINES FOR RAILWAYS

FOUR RECENT EUROPEAN DESIGNS

The remaining five papers in the " Railway Traction " category were discussed at the afternoon session on May 24, presided over by Mr. A. Bourlet, technical director of the Société d'Electricité et de Mécanique (Belgium). They were largely of a descriptive character, Dr. G. Goldbeck (Klöckner-Humboldt-Deutz A.G.) dealing with a series of " Loop-Scavenged Two-stroke Engines for Locomotives " developed by his firm; Dr. Ing. Ekhart Schmidt (Daimler-Benz A.G.) with the design and operation of the high-speed heavy-duty engines built by the Daimler-Benz firm for rail traction; Dr. L. Geislinger (Société des Etudes des Moteurs Thermiques) with a method of transmission devised by the Motala Company in Sweden, in which, by means of a differential, the output of a Diesel engine was divided between an air compressor and the drive to the wheels, part of the compressed air supercharging the engine and the rest, with the exhaust gases, being expanded in a gas turbine; Mr. F. Picard and Mr. M. Chatel described the Renault locomotive, with a combination of free-piston gas generator and a gas turbine, which was the subject of the paper which the former presented to the Institution of Mechanical Engineers on April 22; and Mr. A. Vandaghen, chief engineer of La Société Cockerill, Belgium, who alone did not concern himself with any particular make of engine, discussed the use of the spectrograph in facilitating the maintenance of Diesel locomotives.

The two-stroke loop-scavenged engines described by Dr. Goldbeck are in use on the railways in Sweden and Italy, and have been used also in various marine and stationary applications; it is sufficient to say, therefore, that they are made in a range of six sizes, with from four to 12 cylinders, and outputs from 266 to 1,050 h.p., all at a uniform speed of 750 r.p.m.

The two new designs of Daimler-Benz engines dealt with in Dr. Schmidt's paper were the MB820, a 12-cylinder V-type engine giving 1,000 h.p. at 1,500 r.p.m., and the six-cylinder in-line MB836, delivering 500 h.p. at the same speed. Both engines are fitted with exhaust turbo-chargers, though they are also available without, in which case the outputs are 700 and 350 h.p., respectively; the air for supercharging is cooled before entering the cylinders. It was stated that the MB820 engine had been operated up to a brake mean effective pressure of 17·5 kg. per square centimetre, and a power output of 1,350 h.p., with no sign that the maximum had been reached. Appreciable advantage resulted from the use of high-duty lubricating oils, and particulars of these and other test results were given in the paper.

DIESEL ENGINE AND GAS-TURBINE LINKED

The locomotive described by Dr. Geislinger is of his own patented design and has the 1-D-1 wheel arrangement, with a Bissell truck at each

end. The 16-cylinder four-stroke engine, with a nominal horse-power of 1,060 at 1,000–1,400 r.p.m., is coupled to a special type of gearbox, also designed by Dr. Geislinger, which connects the motor, the compressor, the gas turbine, and the driving axles. A combustion chamber is provided between the Diesel-engine exhaust and the gas turbine, and the portion of the compressor discharge which is not used for supercharging is passed through it. The author stated that the gain due to the combustion chamber was sufficient to compensate for transmission losses, so that, at full power, the power available at the driving axles was equal to that delivered by the Diesel engine.

The Renault experimental locomotive's power unit consists of a gas generator (started on gas oil, but running normally on a light fuel oil) which feeds a gas turbine. The turbine drives the axles through a gearbox and shafts with universal joints. The locomotive has been in service since April, 1953, covering about 250 miles daily with loads of 160 to 200 tons. It is still in process of experimental development, but the tests have shown some encouraging results though certain shortcomings, notably the low effort at starting, have yet to be overcome.

Mr. Vandeghen's paper dealt with the application of spectrographic examination of the lubricating oil from the moving parts of Diesel engines for locomotives, as developed initially on the Denver and Rio Grande Western Railroad in the United States, for the purpose of ensuring systematic maintenance and replacement as necessary of highly-stressed parts. By examining the lubricating oil for traces of lead, copper, iron, chromium and aluminium, it was found possible to detect the existence of undue wearing parts containing those metals.

The discussion on these five papers did not range over a very wide field, most of the few questions relating to points of minor detail. In response to one question regarding the Renault locomotive, Mr. Chatel claimed that the slightly higher fuel consumption of the engine, as compared with normal types, was more than offset by the better overall efficiency of transmission, which he stated to be 90 per cent.; an electric transmission, he said, would give only about 80 per cent., and a hydraulic transmission 70 per cent.

To be continued

ENGINEERING HISTORY IN THE NORTH-EAST

NEWCOMEN SOCIETY SUMMER MEETING

A varied programme was arranged for the party of about 60 members and guests who attended the summer meeting of the Newcomen Society at Newcastle-upon-Tyne from June 7 to 10. The evening of the first day was devoted to a conversazione at Stephenson Building, University of Durham, Claremont-road, Newcastle, by invitation of Dr. C. I. C. Bosanquet, M.A., Hon.D.C.L. (Durham), Rector of King's College. The laboratories were open for inspection, and an exhibition of old prints and drawings had been arranged. The evening meeting concluded with a talk entitled " Teaching the History of Mechanical Engineering to University Students," by Professor Aubrey F. Burstall, D.Sc., Ph.D., M.I.Mech.E., Professor of Mechanical Engineering and Director of the Stephenson Engineering Laboratory.

On the following day, June 8, the party proceeded to the Ryhope pumping station of the Sunderland and South Shields Water Company, where, by permission of Mr. A. G. McLellan, B.Sc., M.I.C.E., M.I.W.E., the company's engineer and general manager, two working beam engines were seen. These engines were built by R. and W. Hawthorne in 1868. They are of the double-acting, compound, rotative type, with Watt pattern parallel motion and centrifugal governors. The cylinders are steam-jacketed, the high-pressure having a bore of 27½ in. and stroke of 5 ft. 4 in., while the low pressure has a bore of 45 in. and stroke of 8 ft. The beams are 33 ft. long and 22 tons in weight. The flywheels are 24 ft. diameter and weigh about 18 tons. The valve gear is operated by a camshaft beneath the valve chest and push-rods as in an internal-combustion engine. Steam is taken from three Galloway Lancashire boilers. The engines raise the water from a well 257 ft. deep in two stages by means of reciprocating bucket pumps of 10 ft. stroke, the pumps being directly coupled to the beam. At the normal operating steam pressure of 40 lb. per square inch, vacuum of 26 in., and speed of 6 r.p.m., each engine raises 40,000 gallons of water per hour and develops about 60 brake horse-power. The engines are excellent examples of mechanical construction in the latter half of last century, and are maintained to the high standard which is normal waterworks practice.

From Ryhope the party travelled to Warden Law, where Mr. W. L. Tulip, area chief engineer, Durham Division, National Coal Board, had arranged for an inspection of the Warden Law haulage engine. This is a single-cylinder beam engine of 39 in. diameter and 6 ft. 2 in. stroke, and was built by Murray, of Chester-le-Street, in 1836. It is used for hauling standard-gauge railway wagons up a 1 in 19 incline, 760 yards long. The incline is part of a colliery line laid down in 1822, with George Stephenson as engineer. Five 12-ton wagons now make up a set, the descending empties helping to balance the ascending loaded wagons; the rope speed is 8 m.p.h. The engine is of orthodox type, with a beam 22 ft. long, Watt pattern parallel motion at the cylinder end, and an 18-ft. connecting rod and crank at the flywheel end. The flywheel, which is 24 ft. 6 in. in diameter, is coupled to rope drums 8 ft. diameter by 2 ft. 6 in. wide. The valve gear is operated by a slip or loose eccentric, and the engine is reversed by depressing a pedal so as to release the eccentric-rod from the weigh-shaft, and operating the valve hand lever to reverse the steam flow. The shaft then turns freely through 180 deg. until a dog on the side plate engages the dog on the eccentric, which is then re-engaged. Steam is taken from Lancashire boilers at 35 lb. per square inch.

The next visit was to Elemore Colliery, Hetton-le-Hole, where Mr. Tulip had arranged for the party to see two winding engines of a type which originated in County Durham and was long in favour there, though it was little used elsewhere. Both engines are basically of the type, patented by Phineas Crowther in 1800, which consist of a vertical cylinder with the crankshaft overhead, and a double-beam parallel motion. The first engine seen by the party, the " Isabella " engine, is of unknown make and age. It has a single cylinder 39 in. diameter by 6 ft. stroke, working at 35 lb. per square inch. The crankshaft, at the top of the engine house, carries a winding drum 15 ft. 10 in. in diameter and 5 ft. 8 in. wide, and a flywheel 23 ft. 9 in. in diameter which forms the brake path; the brake is steam operated. The engine winds from a depth of 600 ft., with three-deck cages, and running at 30 r.p.m., has a rope speed of 25 ft. per second. A balance-chain weighing 24½ lb. per foot is used to counterbalance the cages.

The second engine at Elemore, the " Lady," is of later construction, and departs from the Crowther specification by having two cylinders. The date is unknown, but is approximately 1870; the makers were Davy Brothers, of Sheffield. Each cylinder is 42 in. in diameter by 5 ft. stroke, and steam is used at 55 lb. per square inch. The rope drum is 17 ft. 1 in. in diameter and 6 ft. 3 in. wide, and running at 30 r.p.m. gives a rope speed of 26·7 ft. per second. Four-deck cages are used, the winding depth being 900 ft.

On the return from Elemore to Newcastle the party visited Durham, where tea was taken at the Castle by invitation of Sir James Duff, Kt., M.A., M.Ed., the Warden of Durham Colleges. The party then divided to inspect either the Castle or the Cathedral.

In the evening members and guests were received at the Mansion House by the Lord Mayor of Newcastle, Alderman H. Waller, the Lady Mayoress, Mrs. Swanson, the Sheriff, Alderman Mrs. D. A. Fitzpatrick, and the Sheriff's Lady, Councillor Mrs. C. F. Boothroyd.

On June 9 the Museum of Science and Industry at Newcastle was visited and a brief inspection was made of the large collection of exhibits of engineering interest. The party then proceeded to the works of C. A. Parsons and Company, Limited, Newcastle, where by invitation of Sir Claude Gibb, C.B.E., D.Sc., M.I.Mech.E., F.R.S., the chairman of the company, they were shown round the machine and erecting shops and entertained to lunch.

The afternoon was spent in visiting Killingworth, where George Stephenson lived for a time, and Wylam, where the cottage in which he was born in 1781 was seen. It was remarked that by coincidence visits to the two Stephenson cottages took place on the day, June 9, which was the anniversary of the great engineer's birth. Another item of railway interest which was included in the afternoon excursion was Causey Bridge, near Stanley, County Durham, which was built in 1727, and is claimed to be the oldest existing railway bridge in the world. A stone arch of 100 ft. span, Causey Bridge originally carried a double-track wagon-way of 4-ft. gauge. It has been disused for many years.

In the evening, the Annual Dinner of the Society was held at the Royal Station Hotel, Newcastle, and members welcomed a number of distinguished guests including the Lord Mayor of Newcastle-upon-Tyne, and Dr. Charles Penrose, senior vice-President of the Newcomen Society in North America, who had flown from San Francisco to join the parent Society for the dinner. After the loyal toast and the customary toast to the memory of Thomas Newcomen, Mr. M. W. Flinn, B.A. (member) gave a short address on " Technology and Industry in the Derwent Valley in the 18th Century," in which he described the Winlaton Mill forge, plating mill and steelworks of Ambrose Crowley and his successors.

The last day of the meeting, June 10, was devoted to an inspection of the Roman bridge remains at Chesters, near Chollerford, and the Roman fort at Housesteads on the Roman Wall, under the guidance of Professor Ian A. Richmond, M.A., Professor of Roman-British Archaeology, Durham University. At Chesters the military road which ran parallel with the Roman Wall crossed the North Tyne, and a movement of the river since Roman times has destroyed the western abutment of the bridge, leaving the eastern one exposed on dry land. Professor Richmond pointed out that in later Roman days the fort at the bridge had been converted into a corn mill, and traces of this were clearly visible. Later additions to the downstream side of the abutment could also be seen, where alterations had been necessary to combat scour. At the Roman fort at Housesteads there was only sufficient time to examine part of the extensive ruins, but the water supply and sanitary arrangements proved of particular interest.

In the evening of June 10 there was a conversazione at the Royal Station Hotel, Newcastle, where members were the guests of the North-East Coast Institution of Engineers and Shipbuilders, and were received by Mr. Mungo Campbell, past-President of the Institution, in the absence abroad of the President, Mr. P. L. Jones, M.C., B.Sc., M.I.Mech.E. This was the concluding event of the summer meeting.

PERSONAL

The General Committee of Lloyd's Register of Shipping, 71, Fenchurch-street, London, E.C.3, have re-elected SIR RONALD GARRETT chairman for the ensuing year. SIR GUY ROPNER has been re-elected deputy-chairman and chairman of the sub-committees of classification, MR. J. E. GREEN, deputy-chairman and treasurer, and MR. R. M. TURNBULL, vice-chairman of the sub-committees of classification. MR. H. R. GIBBS, principal surveyor at Glasgow, has been appointed principal surveyor for Scotland.

LORD TWEEDSMUIR, O.B.E., LL.D., has accepted the invitation of the Minister of Transport and Civil Aviation to join the board of the British Overseas Airways Corporation with effect from June 6.

REAR ADMIRAL J. G. C. GIVEN, C.B., C.B.E., M.I.Mech.E., M.I.Mar.E., whose approaching retirement after 35 years in the Engineering Branch of the Royal Navy was announced on page 585 *ante*, has been elected to the board of Parsons Marine Turbine Co. Ltd., Turbinia Works, Wallsend-on-tyne. He will succeed MR. ANDREW HOPPER as managing director at the end of this year, when Mr. Hopper retires after 54 years of service with the company.

DR. E. S. MOULT, B.Sc.(Eng.), M.I.Mech.E., F.R.Ae.S., chief engineer of the de Havilland Engine Co. Ltd., has been elected a director of the company as from June 1.

MR. STANLEY VAUGHAN, B.Sc., M.I.C.E., A.C.G.I., has been elected President of the Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1, for the session 1955–56. He will take office in October.

The Senate of the University of London have conferred the degree of D.Sc.(Eng.) on DR. A. ROSEN, M.I.E.E., for his work in the field of telecommunication cables.

MR. STANLEY S. DAWES, M.I.Mech.E., F.C.C.S., President of the Institute of the Motor Industry, 40 Queen's Gate, London, S.W.7, has been elected a vice-president of the Fédération Internationale des Sociétés d'Ingénieurs et de Techniciens de l'Automobile. He has also been elected to honorary membership of the Associazione Tecnica Automobile, Italy.

MR. W. F. JOHNSTON, M.I.Mech.E., M.I.F., chief engineer to Edwin Danks & Co. (Oldbury) Ltd., has retired and has been succeeded by MR. H. MCANDREW, A.M.I.Mech.E., who has been deputy chief engineer since 1952.

MR. F. J. W. W. DIGBY, M.A., F.R.Ae.S., formerly chief designer, Westland Aircraft Co. Ltd., has joined Folland Aircraft Ltd., Hamble, Southampton, as an assistant chief designer for work on impending projects.

MR. J. A. T. DICKINSON, O.B.E., works director of the Small Heath Group, B.S.A. Co. Ltd., Birmingham 11, has retired after 40 years with the company.

MR. R. S. ATKINSON, A.M.I.Mech.E., A.M.I.E.E., deputy chief generation engineer (operation) in the North West, Merseyside and North Wales Division, Central Electricity Authority, has been appointed chief generation engineer (operation) in the South Wales Division. He succeeds MR. E. HYWEL JONES, M.I.E.E., M.I.Mech.E., who has been appointed deputy chief engineer (generation) of the South of Scotland Electricity Board. MR. G. B. JACKSON, D.F.H., has been appointed power circuit engineer in the chief engineer's department at headquarters.

MR. R. W. BURCHHARDT, technical manager, Colloidal Graphite Ltd., 6 & 7 St. Dunstan's Lane, London, E.C.3, has been elected a director.

The Ministry of Supply announce that MR. F. E. MCGINNETY has been promoted to the position of deputy chief scientific officer and has been appointed director, Inspectorate of Electrical and Mechanical Equipment, with effect from July 1.

MR. H. N. RIDLEY, director of the Singapore Botanic Gardens from 1888 to 1912, who is now in his hundredth year, has been awarded a special Colwyn Gold Medal by the Institution of the Rubber Industry for his services in connection with the creation of the Malayan rubber industry.

MR. K. J. CLARKE, A.M.I.E.E., has been appointed assistant manager, Sheffield district office, of the British Thomson-Houston Co. Ltd., Rugby, with effect from June 1.

MR. WILLIAM WALKER, on account of his business commitments, has relinquished his directorship of Singer Motors Ltd.

In connection with the appointment of MR. R. Q. WILSON as United Kingdom representative of the Battelle Memorial Institute, announced on page 719 *ante*, we now learn that DR. H. E. Z. GORDON, who, until recently, has been active as the Battelle United Kingdom representative, is now devoting himself to the interests of the Battelle Development Co. Ltd., of which he is general manager.

* * *

COMMERCIAL

A group of firms who have had close association with the UNITED KINGDOM ATOMIC ENERGY AUTHORITY in the design and construction of the CALDER HALL ATOMIC POWER STATION, or who have special experience and facilities for such work, are associated with a recently incorporated separate company, the NUCLEAR POWER PLANT CO. LTD., which will concentrate on the design and construction of nuclear power stations. The registered office is at Heaton Works, Newcastle-upon-Tyne, and the design headquarters at Booths Hall, Knutsford, Cheshire. The associated firms are: C. A. PARSONS & CO. LTD., A. REYROLLE & CO. LTD., HEAD, WRIGHTSON & CO. LTD., SIR ROBERT MCALPINE & SONS, LTD., WHESSOE LTD., STRACHAN & HENSHAW LTD., ALEX. FINDLAY & CO. LTD., and CLARKE, CHAPMAN & CO. LTD. The President and chairman of the Nuclear Power Plant Co. is SIR CLAUDE GIBB, C.B.E., D.Sc., F.R.S., and the other directors are DR. A. T. BOWDEN, M.I.Mech.E., MR. R. EDWIN MCALPINE, MR. RICHARD MILES, B.Sc., M.I.Mech.E., MR. H. H. MULLENS, B.Sc., M.I.E.E., MR. A. J. SAYERS, A.M.I.E.E., and SIR JOHN WRIGHTSON, Bt., T.D. The secretary is MR. D. P WALTON, A.C.A.

The name of the PARSONS' MARINE STEAM TURBINE CO. LTD. has been changed to PARSONS MARINE TURBINE CO. LTD., Turbinia Works, Wallsend-on-Tyne. The constitution and control of the company remain unchanged.

EDGAR ALLEN & CO. LTD., Imperial Steel Works, Sheffield, 9, have acquired the business of makers of electro-magnetic chucks and demagnetisers carried on by J. H. HUMPHREYS & SONS, Oldham. The business will continue to be conducted, but as a limited company, at the Blackriding Electrical Works, Werneth, Oldham, and MR. ALBERT HUMPHREYS, who has joined the board of the new company, and MR. AUGUSTUS HUMPHREYS, both partners in the original firm, have agreed to serve the company for the time being. All other members of the staff and workpeople will continue to be employed.

The new address of BEIER INFINITELY VARIABLE GEAR CO., LTD., is 1 Cornwall-road, London, S.E.1. (Telephone: WATerloo 3854.)

W. H. BECK & CO. are changing their title and address, as from June 24, to W. H. BECK, GREENER & CO., 7 Stone Buildings, Lincoln's Inn, London, W.C.2. For the time being the business will remain in the sole charge and control of MR. F. W. G. GREENER.

MARTIN, BLACK & CO. (WIRE ROPES) LTD., Coatbridge, Lanarkshire, have opened two new depots to cover the Midland and North-West areas of England. At Nottingham, the office is at 4 Low Pavement (Telephone: Nottingham 47293-4), and the stores at 640 Woodborough-road, Mapperley (Nottingham 64397). At Liverpool, the office is at Century Building, North John-street (Telephone: Liverpool Central 0924) and the stores at 99A Webster-road (Sefton Park 6669).

AIR SERVICE TRAINING, Hamble, Southampton, a member organisation of the HAWKER SIDDELEY GROUP, is to open a helicopter school for training air-line pilots or private persons and also helicopter maintenance staff. The first courses are to begin in August.

In accordance with a recommendation of the Advisory Committee on the NATIONAL COAL BOARD'S organisation, a purchasing and stores department is being set up as from July 1. The Board member responsible for the department is MR. R. H. E. THOMAS, O.B.E.

The entire AUTOMOBILE GEARBOX DIVISION of DAVID BROWN AND SONS (HUDDERSFIELD) LTD. has been moved bodily to a new, self-contained factory alongside the main works at Lockwood, Huddersfield.

GEORGE KENT LTD., Luton, Bedfordshire, have begun work on a new factory at Hitchin, Hertfordshire, for the manufacture of steering gears for the motor-car industry (marketed through CAM GEARS LTD.).

GALITZINE AND PARTNERS, international public-relations consultants, have now moved to 17 Victoria-street, Westminster, London, S.W.1. (Telephone: ABBey 4013.)

RHODEN PARTNERS LTD., design and development engineers, are removing from 6 Ganton-street, London, W.1, to larger premises at 51 North-row, London, W.1 (Telephone: MAYfair 6248) on June 18.

WEST PRODUCTS (METALS) LTD., 161 High-street, Hampton Hill, Middlesex (Telephone: Molesey 1784) have established a plant for the production of investment castings in steel alloys and in copper-base, aluminium, magnesium and titanium alloys.

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Letters to the Editor

LARGE GIRDER FABRICATION IN THE UNITED KINGDOM

SIR, In the article entitled "Rust-Proofing Large Bridge Girders," on page 702 of ENGINEERING (June 3), it was suggested that the steel-plate girders, 128 ft. long by 10 ft. deep and 2 ft. over flanges, described therein are the largest of their type yet made in the United Kingdom.

In the alterations carried out at Paddington during 1930-33 by the former Great Western Railway Company, a hog-backed plate girder of 133 ft. 1¾ in. overall length, 8 ft. 6 in. deep at end posts and 15 ft. deep at centre with a width of 2 ft. 9 in. over flanges was provided to carry the road serving Paddington Goods Station over the tracks of the Hammersmith and City Line. The girder was fabricated by Dorman Long and Company on a site about 50 ft. from, and parallel to, the final position of the girder, and rolled into position in about eleven minutes. The main contractor on that occasion was also Messrs. Caffin and Company.

Yours faithfully,
M. G. R. SMITH,
Chief Civil Engineer.

Western Region,
Paddington Station,
London, W.2.
June 13, 1955.

* * *

OPTIMUM SIZES OF RAILWAY WAGONS

SIR, I found the article on the optimum sizes of railway wagons, in your issue of March 18, very interesting and informative and I am wondering whether I may ask for a little clarification.

On page 349, after conclusion (*c*), Mr. Mills states "these conclusions assume that the *length* (my italics) of a train is its limiting factor." Again in the same column in the paragraph beginning with the small letter (*b*) "where the length of a train is the limitation." The doubt in my mind is whether Mr. Mills really means length, or the total weight which (having regard to the resistance of the particular type and size of vehicle concerned) a locomotive of any given power could haul.

Yours faithfully,
J. C. BOUSTEAD.

Rock House,
Vicarage Lane,
Duffield, Derbyshire.
June 9, 1955.

* * *

CONTRACTS

Power-station, Transforming-station and Transmission-line Equipment. During April, contracts were placed by the Central Electricity Authority for power-station, transforming-station and transmission-line equipment, amounting, in the aggregate, to £17,955,750. The principal contracts include: For Portishead "B" power station, near Bristol: condensing and feed-heating plant for one 60,000 kW turbo-generator set, with the METROPOLITAN-VICKERS ELECTRICAL CO. LTD. For Tilbury power station: ash and dust-handling plant, with BABCOCK AND WILCOX LTD. For Castle Donington power station, near Derby: one 100,000 kW turbo-generator, feed-heating and evaporating plant, with the METROPOLITAN-VICKERS ELECTRICAL CO. LTD., and high-pressure pipe-work and valves, with AITON & CO. LTD.

For Willington "A" power station, near Derby; main civil-engineering works, with MARPLES, RIDGWAY AND PARTNERS LTD.; one 100,000 kW turbo-generator, condensing and feed-heating plants, with the ENGLISH ELECTRIC CO. LTD., and 132 kV 3,500 MVA switchgear, with the GENERAL ELECTRIC CO. LTD. For Rogerstone power station, Monmouthshire: the main civil works, with SIR ROBERT MCALPINE & SONS (SOUTH WALES) LTD., and structural steelwork, with BRAITHWAITES & CO. (STRUCTURAL) LTD. For Elland power station, Yorkshire: the main foundations and circulating-water system, with YORKSHIRE HENNEBIQUE CONTRACTING CO. LTD., and 132 kV, 3,500 MVA switchgear, with the ENGLISH ELECTRIC CO. LTD. For Skelton Grange "B" power station, Leeds: two 60,000 kW turbo-generators and two generator transformers, with C. A. PARSONS & CO. LTD.; condensing and feed-heating plants for two 60,000 kW sets, with G. & J. WEIR LTD., and a 60,000 kW turbo-generator set and condensing and feed-heating plants, with RICHARDSONS, WESTGARTH (HARTLEPOOL) LTD. For Mexborough power station, Yorkshire, 66 kV, 1,500 MVA switchgear with the ENGLISH ELECTRIC CO. LTD. For Blyth "A" power station, Northumberland: two 120,000 kW turbo-generators, with the METROPOLITAN-VICKERS ELECTRICAL CO. LTD. For Stella South power station, near Newcastle-upon-Tyne: a 72 MVA 141·6/11·8 kV generator transformer, with C. A. PARSONS & CO. LTD. For Iver, Bucks.,: two MVA 275/66 kV transformers, with CROMPTON PARKINSON LTD. For Coalville, Leicestershire: 132 kV 2,500 MVA switchgear, with A. REYROLLE CO. LTD. For Connah's Quay, near Flint: 132 kV 3,500 MVA switchgear, with FERGUSON PAILIN LTD. For Agecroft, Salford: 132 kV overhead line, with W. T. HENLEY'S TELEGRAPH WORKS CO. LTD. For Hams Hall, near Birmingham: 275 kV overhead line, with BRITISH INSULATED CALLENDER'S CABLES LTD.

Highway Bridge. A contract to the value of £450,000 has been awarded to SIR WILLIAM ARROL & CO. LTD., Glasgow, for the complete construction of embankment approach roads, piled abutments and river piers and the steel superstructure of a new highway bridge over the River Euphrates at Samawa, about 175 miles south of Baghdad. The overall length spanning the river of 527 ft. comprises a central span of 261 ft. between the river piers which carry the main towers, and two side spans, each of 133 ft., from pier to abutment. The structure, a suspension bridge of the self-anchoring type, provides a carriageway, 26 ft. 3 in. wide between the main stiffening girders and two footways each 6 ft. 6 in. wide cantilevered on the outside of the girders. The entire superstructure totalling about 800 tons will be of high-tensile steel. The work is to be executed to the order of the Iraq Development Board and the consulting engineers are MESSRS. MAUNSELL, POSFORD AND PAVRY, of London, S.W.1.

Gas Dehydration Plants. In conjunction with the FLUOR CORPORATION LTD., HEAD WRIGHTSON PROCESSES LTD., Teesdale House, 24–26 Baltic-street, London, E.C.1, have received an order for two gas dehydration plants to dehydrate 18 million cub. ft. of gas daily for the Gas and Fuel Corporation of Australia. Situated at Morwell, Victoria, the plants will process gas extracted from the brown-coal deposits nearby, and supplies will be piped to the City of Melbourne.

Hydro-Electric Works Dam and Tunnel. The North of Scotland Hydro-Electric Board have placed the first of the main contracts for their Orrin hydro-electric scheme. DUNCAN LOGAN (CONTRACTORS) LTD., Muir of Ord, Ross-shire, have been awarded the contract to build the Orrin dam, five miles upstream from the Orrin Falls. The dam will be 150 ft. high and 1,000 ft. long. WHATLINGS LTD., Glasgow, have been given the contract to build the 16,000-ft. long tunnel which will carry water from the new reservoir formed by the Orrin dam to a power station in Strathconon, near Achonokie, on the southern shore of the small loch created by the Torr Achilty dam. This power station will have a total capacity of 18,000kW. The value of the contract is approximately £4,300,000. The Orrin scheme, which is the third stage of the Conon Valley development, will harness the water-power resources of an area extending to 54 sq. miles and draining into the River Orrin. The annual production of electricity from the scheme will be about 80 million units.

Diesel Engines. An order for 548 Diesel engines for direct export has been placed with F. PERKINS LTD., Peterborough, by P. Petropoulus & Co., the firm's distributors in Greece.

Obituary

SIR ATHOL ANDERSON, K.C.B.

Former Civil Engineer-in-Chief, Admiralty

We regret to record that Sir Athol Anderson, K.C.B., who from 1934 to 1940 was the civil engineer-in-chief at the Admiralty, died at his home in Hove on June 7 at the age of 80.

Athol Lancelot Anderson was born on January 17, 1875, and received his general education at Cheltenham College from 1889 to 1891, passing the preliminary examination for the army in December, 1890. In August, 1891, he was articled for three years to Mr. (later Sir James) Lemon of Messrs. Lemon and Blizard of Southampton and Westminster. On completion of his articles he was appointed an assistant to the firm and for a period during 1895-96 was resident engineer in charge of drainage and roadworks on the Stonewood Estate, Christchurch. In May, 1896, he joined the late Mr. H. W. Anderson as an assistant and was engaged on extensions for a cement works and on the erection of workshops for Aveling and Porter, Limited, Rochester.

His connection with dockyards began as early as May, 1897, though it was not until December, 1899, that he was to enter the Admiralty and in the following year to pass first in open competition for assistant civil engineers. The intervening period had been spent first as a pupil and later as a draughtsman at Stothert and Pitt, Limited, Bath.

From 1901 he served as an assistant under the then civil engineers-in-chief at various naval establishments at home and abroad. This work included the construction of river walls and gun batteries at Portsmouth, and it was at this time that he was elected an associate member of the Institution of Civil Engineers. From 1903 to 1907 he served in Malta on the construction of the breakwater and later engagements took him to Rosyth, Hongkong, Simonstown, Jamaica, Heligoland and Singapore. In 1908 he went to Jamaica to report for the Admiralty on the damage caused by earthquakes to H.M. Dockyard and Naval Establishments. During the 1914-18 war he served in the Far East with the rank of lieutenant, R.N.V.R., afterwards returning to the Admiralty.

In 1929 he was appointed a superintending civil engineer at the Admiralty and in 1932 was promoted deputy civil engineer-in-chief. Two years later he assumed full control of the department as civil engineer-in-chief, a position he held with distinction until his retirement in 1940. He was elected a member of Council of the Institution in November, 1936, and continued to serve the profession in that capacity until November, 1941. He was made a C.B. in 1936 and advanced to K.C.B. in 1939.

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SIR CHARLES McLAREN, K.C.B.

Ordnance Factories in War

It is with regret that we note the death in a London hospital, on June 8, of Sir Charles McLaren, late Director-General, Royal Ordnance Factories, Ministry of Supply. Charles Northrup McLaren was the eldest son of Mr. D. D. McLaren and was born in Glasgow on October 14, 1898. He received his general education at Bellahouston Academy and, in 1914, at the age of 16, became an apprentice in the works of P. and W. McLellan, Limited, Glasgow, meanwhile continuing his education in mechanical engineering subjects in the Royal Technical College. His pupilage was interrupted for two years by war service but on its completion, in 1920, he joined the staff of Redpath, Brown and Company, Limited, Edinburgh, as a draughtsman and erection engineer. In subsequent years he gained much experience as efficiency engineer or works manager in a number of firms.

He left this firm in 1931 to take up the post of superintendent of labour at the Royal Arsenal, Woolwich. Four years later McLaren was made superintendent of labour of the Royal Gun and Carriage Factories at Woolwich and, in 1936, became assistant director of the Royal Ordnance Factories. In 1938 he succeeded the late Sir Reginald Townsend, K.C.B., as Director of Royal Ordnance Factories and two years later was made Director General. As such he was directly responsible to the Minister of Supply for the administration of all the Royal Ordnance Factories, then an extremely onerous position, and the fact that he was created a K.C.B. in 1941, at the relatively early age of 43 and after only ten years in the Government service, was an indication of the manner in which he discharged his duties. Sir Charles, however, was obliged to give up his work and retire in 1951 on account of ill health.

He was for a number of years a member of the Institution of Production Engineers and was elected a member of the Institution of Mechanical Engineers in 1941.

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We regret also to record the deaths of:

MR. JOSEPH BRADLEY, O.B.E., B.A., B.A.I. (Dublin), A.M.I.C.E., at Dalkey, County Dublin, on June 1, at the age of 63. A graduate of Trinity College, Dublin, he joined the staff of the Engineering Department, National Physical Laboratory, Teddington, Middlesex, as a scientific officer in 1923. Mr. Bradley remained at Teddington until some 10 years ago when he entered the National Institute of Agricultural Engineering, first at Askham Bryan, York, and latterly, until his retirement recently, at Wrest Park, Bedford.

MR. IAN CECIL EASTON, B.Sc.(Glas.), M.I.Mun.E., A.M.I.C.E., in Glasgow on June 5. After graduating at the University of Glasgow in 1929 he entered the office of the engineer of the Birmingham, Tame and Rea District Drainage Board, Erdington, Birmingham. Mr. Easton subsequently served for some ten years in the office of the City Engineer, Bristol, after which he became an engineering assistant in the Borough Engineer's office at Bootle. Some years ago he joined Messrs. James Williamson & Partners, consulting engineers, Glasgow, and in 1952 was appointed lecturer in civil engineering at the Royal Technical College, Glasgow.

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ASLIB MEETING

New Members of Council

At the annual general meeting of Aslib, held at the Trocadero Restaurant, London, on June 10, Sir Raymond Streat, C.B.E., was appointed President for the year 1955-56. Past Presidents who will serve on the Council are Professor Barbara Wootton, M.A., L.H.D., J.P., and Professor Sir Arnold Plant, B.Com., B.Sc. (Econ.). Sir Andrew McCance, A.R.S.M., M.I.Mech.E., F.R.S., and Professor Sir Alexander Todd, D.Sc., F.R.I.C., F.R.S., were appointed Vice-Presidents. Mrs. J. Lancaster-Jones, B.Sc., and Mr. J. E. Wright were appointed honorary secretary and honorary treasurer respectively.

The following members were elected to fill the eleven vacancies on the Council: Mr. E. Alan Baker, librarian, Ministry of Food; Mr. A. R. Cameron, technical librarian, A. V. Roe and Company, Limited; Mr. C. W. Cleverdon, librarian, College of Aeronautics; Miss Barbara Kyle, individual member; Mr. J. D. Pearson, librarian, School of Oriental and African Studies, London University; Mr. D. T. Richnell, deputy librarian, London University; Mr. G. A. Shires, technical information officer, Dunlop Research Centre; Mr. F. H. Smith, librarian, Royal Aeronautical Society; Mrs. M. Spence, librarian and information officer, Cerebos, Limited; Mr. J. R. Stocks, head of technical information section, Shell Petroleum Company, Limited; and Mr. R. R. Stokes, head of School of Librarianship, Loughborough College of Further Education.

The annual general meeting was preceded by a luncheon, at which the Editor of *The Times*, Sir William Haley, K.C.M.G., LL.D., gave a thought-provoking address on the Press and the B.B.C.

BOOK REVIEWS

Sonics: Techniques for the Use of Sound and Ultrasound in Engineering and Science. By THEODOR F. HUETER and RICHARD H. BOLT. *John Wiley and Sons, Incorporated*, 440 *Fourth-avenue, New York* 16, *N.Y., U.S.A.* (10 dols.); and *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (80*s.*)

The list of works on acoustics from the Massachusetts Institute of Technology is already an impressive one. This latest addition is, as its sub-title indicates, devoted to those industrial applications of mechanical vibrations, both within and above the audible range, that are already well established and to others which are likely to assume increasing importance in the near future. The main purpose of its authors is to bring out the basic physical principles underlying the use of sound and ultrasound for such diverse purposes as metal testing, spot welding, drilling, gas analysis, medical diagnosis, aerosol agglomeration, fish location, clothes washing and degreasing. Only when these general principles are thoroughly understood is it possible to analyse any given situation and choose the type of generator and the particular frequency best suited to the task in hand.

An outline of the fundamentals of vibration and sound is given at the outset, the mathematical discussion being kept as simple as possible and limited to the linear range. Particular attention is paid to sound waves in fluids, transfer of energy across interfaces and radiation pressure. The usefulness of electrical analogies is stressed and, as is customary in modern literature on acoustics, an adequate knowledge of the theory of electrical circuits is assumed. In the treatment of radiation the distinction between the near and far fields is clearly brought out. The directivity functions for a number of simple sources are considered along with other applications of Huygen's principle, while general results for scattering from rigid cylinders and spheres are stated without proof. Electrical energy can be transformed into mechanical energy by several different physical processes, compactly summarised in one of many useful tables, and two chapters are devoted to a comprehensive account of the theory and practice of piezo-electric and magneto-strictive transducers. In the first, due consideration is given to such important matters as power conversion and matching, resonance and anti-resonance, multiple layer (sandwich) transducers and vibration pick-ups. In the second, stress is laid on the influence of eddy currents and hysteresis upon efficiency and the possibility of improving this by suitably designed laminated stacks.

The second half of the book is concerned with applications of sonics in analysis and processing. In the analytical applications, such as flaw detection, underwater signalling, determination of elastic and molecular properties, small amplitudes suffice as only enough power is required to yield an interpretable signal and the transmission medium is not affected. In processing, on the other hand, large amplitudes are required in order to provide the power needed to modify the medium in some particular way, to produce, for example, degassing, emulsification, coagulation or surface cleaning. The behaviour of large-amplitude sound and its effects on materials is considered, in Chapter 6, first in broad outline and then with particular reference to aerosols, where the oscillatory motion communicated to the suspended particles leads to their coagulation, to cavitation in liquids and associated effects such as the cavitation pitting of solid surfaces. The following chapter contains valuable directions for the design of generating equipment to meet the special demands of sonic processing. These generators include, besides piezo-electric and magneto-strictive transducers, sirens, jets and whistles operating on fluid dynamic principles and other devices driven by mechanical forces or heat. The optimum frequencies for most power applications fall in the range between 1 kc/s and 20 kc/s for gases and in the range from 10 kc/s to 400 kc/s for liquids (and melts). Some details are also given of two mechanical methods for generating large forces at low frequencies (20 to 50 c/s) which have lately found practical application in sonic well drilling and to the shear processing of paper pulp. In the final chapter the principles underlying the basic measurements involved in sonic analysis are discussed. All such measurements are shown to involve either times, lengths or energy losses and the appropriate standing wave, continuous (progressive) wave, reverberation and pulse techniques are described together with the relevant circuits. An appendix on acoustical relaxation mechanisms in fluids deals with molecular aspects of particular interest in modern physics.

The judicious balance maintained throughout between the underlying acoustical and electrical principles and their industrial applications in the sonic field makes this a work of the greatest practical importance as well as of the highest scientific interest.

Liberal Education in a Technical Age. Published for the National Institute of Adult Education by *Max Parrish and Company, Limited*, 55 *Queen Anne-street, London, W.*1. (6*s.*)

There is a growing anxiety among thoughtful people at the degree to which modern large-scale society has led to the increasing narrowness of the individual. The scientific complexity of modern inventions and the pace at which they are being developed are leading to an increasing specialisation among those who have to use the new technical skills, and the size of modern organisations, whether public authorities or commercial companies, is doing the same for those who work in the non-technical departments. The demands of the universities and of the professional associations are pushing the start of specialisation back into the schools, so that there is a danger that even those who complete a grammar school education may no longer be considered fully educated.

The majority of our population still leave the secondary modern schools at 15 and are immediately plunged either into learning a trade or into mind-deadening unskilled occupations. The consequences in a democratic society, in which leisure is increasing, could be serious. The National Institute of adult Education, with these ideas in mind, recently made a survey of the relationship of vocational and non-vocational further education and training and this volume is the report which resulted from it. They state that they have no doubt that vocational education is too narrowly conceived, whether considered from the point of view of the individual student or of the well-being of society. A good deal of the trouble arises out of the tradition of technical education in this country, which had its origins in the Technical Instruction Act of 1889. The technical institutes established under that Act interpreted their function in a narrow sense and that tendency has continued in the technical colleges established since. Under the 1944 Act, the duty which is laid on local education authorities to provide post-school education is not confined to vocational education, but when money has been short there has been a tendency to restrict such provision to the purely technical. This restriction was encouraged by Circular 245 sent out by the Ministry of Education in 1952, which ruled out building in technical colleges for social activities.

By far the largest number of those in receipt of further education receive it at a technical college or institution or at a college of art. Nearly 2¼ million students attend classes in these establishments, 56,000 of them full-time, 350,000 during part-time day release from their employment and the balance in the evening. The vast majority, especially the male students, are taking craft, technical or professional courses. To a large extent industry and the examining bodies are to blame, for the time available, at any rate to the evening student, is not sufficient for the inclusion of other than the strictly necessary examination subjects. This is less true in the case of part-time students and not at all in the case of those studying full time. Nevertheless, in spite of the acceptance by principals and teachers of the need for the inclusion of more liberal studies, the number of colleges including them in courses is negligible.

What little teaching in the humanities and the social sciences is being given to young men and women who have not had the advantage of going to a university is being done largely by the university extra-mural departments or by the Workers' Educational Association and, to a growing extent, by the very small number of residential colleges. An interesting feature of the work of these bodies is the growth of demand for types of courses which, while dealing with the general principles of such subjects as economics, history and psychology, are related to the daily activities of the students in industry, either as supervisors or as trade unionists. It is the demand for these courses, in which the boundary between "vocational" and "non-vocational" work is becoming increasingly blurred, that led the Ashby Committee, set up by the Government to inquire into the organisation of adult education, to recommend that courses should not, as heretofore, be excluded from grant merely because they might have a vocational interest for some students. This development corresponds with the views of teachers in technical institutions on the best way of promoting broader interest among their students. The most promising method, in the view of those who answered the inquiry sent to them by the committee which conducted this survey, was the broadening of the technical syllabus itself and most of them thought themselves competent to undertake this development.

In the view of the committee the problem can be resolved only when all concerned, whether in industry, commerce or public administration, share the serious concern of the minority. This should lead to a readiness to extend day release and an insistence on its including non-vocational as well as vocational studies. They are forced to the conclusion that lack of time must exclude the values of a liberal education from vocational work undertaken by evening students, except such as can be introduced by a broader treatment of the technical subject itself, which must be limited by the very nature of some of the subjects. In all full-time, sandwich and day-release courses an effective proportion of the students' time should be allotted to non-vocational work and for this purpose every technical college should have a department of general studies with its own staff, accommodation and courses. The committee also say that they are impressed by the value, for all kinds of students, of short periods in residential colleges.

On the question of subjects, the committee define a liberal education as "one which includes a training in the use of language, in the handling of ideas, in recognising relationships, and in establishing values as touchstones by which questions of taste and morals are to be tested." Nearly all the teachers agree on the importance of English, and in particular of English literature, as the background to a liberal education, and the committee emphasise the responsibility of all teachers to improve their students' use of English as the essential means of thought and communication. There should also be a wider study of human relations in industry and commerce and more emphasis on the aesthetic appreciation of design in the teaching of some subjects. Finally, although the importance of the teacher not being handicapped by having to work in bad conditions is recognised, the need for conferences and short courses to enable technical teachers themselves to learn ways of broadening their vocational teaching is also emphasised.

A liberal education is needed in a technological age, so that the worker at every level may be self-reliant, wise and adaptable and, not least, proud of his calling. This is not simply an educational but a social problem, bound up with our society's scheme of values, and its solution will have a profound effect upon them.

BOOKS RECEIVED

Some of the books noticed here are selected for extended review in ENGINEERING.

Venezuela. Overseas Economic Survey. By R. S. SCRIVENER. Published for the Board of Trade, Commercial Relations and Exports Department, by *H.M. Stationery Office, Kingsway, London, W.C.2.* (3*s.* 6*d.*)

It is the present policy of the Venezuelan Government to invest the large earnings from oil in the expansion of secondary industry, of electric power, and of roads, railways, waterways and other communications. Venezuela thus offers a large market to United Kingdom exporters, but the author of the survey warns that personal contacts are all-important, and Caracas business men maintain that, in the past, too many catalogues from the United Kingdom are printed in English, quotations are often in sterling, and little has been done to accommodate the wishes of this expanding market. The survey points out that particular attention should be paid to the supply of capital equipment, especially electrification and transport materials.

Metallurgical Progress: First and Second Series of Critical Reviews. Published for " Iron and Steel " by *The Louis Cassier Company, Limited, Dorset House, Stamford-street, London, S.E.*1. (4*s.* 6*d.* each.)

The task of reviewing the literature contained in scientific publications on various metallurgical subjects has been undertaken by members of the staff of the Royal Technical College, Glasgow. The results of their search together with discussions of the relative merits of the investigations carried out during the past 30 years have been published as articles in the monthly journal *Iron and Steel.* These articles have been reprinted in the form of two booklets. The first contains reviews by Dr. J. Taylor on " Iron-making "; by Dr. P. T. Carter, on " Steel-making Reactions " ; and by Dr. T. B. King on the " Solidification of Steel." The second booklet contains reviews on the " Preparation of Ores," by Dr. J. M. McLeod; on " Electric Steel Production " by Dr. D. D. Howat; and on " Non-Metallic Inclusions," by Dr. H. B. Bell.

A Treatise on Surveying. Vol. I: Instruments and Basic Techniques. Vol. II: More Advanced Techniques and Modern Developments. Edited by Professor W. FISHER CASSIE. Sixth edition. *E. and F. N. Spon, Limited,* 15 *Bedford-street, London, W.C.*2. (32*s.* 6*d.* each volume.)

The first edition of this work—the present is the sixth—was published in 1899, and was intended to meet the needs of engineers proceeding overseas where a good knowledge of geodetic surveying was required. With the current efforts of the United Nations to open up many of the under-developed territories the need for competent surveyors is no less now than then. Since the fifth edition in 1935, however, many improvements have been made in the design and construction of the instruments available and the present volumes have been brought right up to date. Included in volume II—Advanced Techniques—are chapters on photogrammetry and specific discussions on making engineering surveys for large projects.

The Chemistry of Portland Cement. By R. H. BOGUE. Second edition. *Reinhold Publishing Corporation,* 430 *Park-avenue, New York* 22, *N.Y., U.S.A.* (16·50 dols.); and *Chapman and Hall, Limited,* 37 *Essex-street, London, W.C.*2. (132*s.*)

The second edition of an already successful book, Dr. Bogue's revised volume reports the most recent developments in cement chemistry and technology. New methods described include X-ray techniques for studying single crystals to establish the atomic structure of cement compounds; new uses of the electron microscope and electron diffraction apparatus are described for examining the morphology of materials. The application of differential thermal analysis and spectroscopic analysis, and the result of the recent crystal-structure studies of both anhydrous compounds and the hydrated materials in cement pastes are reported in full. Previous work, including the early work of the last century, is also mentioned in sufficient detail to make the book far more than a handbook of cement practice.

Specification for Dry Cells and Batteries. U.S. National Bureau of Standards Circular 559. *The Superintendent of Documents, U.S. Government Printing Office, Washington* 25, *D.C., U.S.A.* (25 cents.)

This specification includes definitions, nomenclature, nominal voltages, general classification, standard sizes, materials and workmanship, top closure, terminals, and standard tests of cells and batteries.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Tractor Attachments. HYSTER CO., 2902 N.E. Clackamas-street, Portland 8, Oregon, U.S.A.; United Kingdom Caterpillar Dealers, 4 Tilney-street, London, W.1. Attachments, including excavator crane, grid roller, yarders, winches, etc., for effecting economies using tractor tools for fill compacting, trenching, shovelling, pile driving, etc. Illustrated booklet entitled *Nine Profitable Minutes for Contractors.*

Treatment of Trade Effluents. AMES CROSTA MILLS & CO., LTD., Heywood, Lancashire. Techniques and equipment for purification of trade effluents. Legal position, general principles of treatment and types of effluent. Trades covered include: paper, metal plating and pickling, oil and chemicals, textiles, tanneries, dairies, canneries, farms and food production. Illustrated booklet and questionnaire.

Diesel Engines for Rail Traction. DAVEY, PAXMAN & CO. LTD., Colchester. Normally-aspirated and supercharged Diesel engines particularly for rail-traction work. YH range, from 200 to 1,000 b.h.p. direct injection, four stroke, 7-in. bore by 7¾-in. stroke; and YL range 500 to 2,000 b.h.p., four stroke, 9¾-in. bore by 10½-in. stroke. Full details in brochures Nos. 1407 and 1408 respectively.

Relief-Valve in Glass. Q.V.F. LTD., Mill-street, Stone, Staffordshire. Pressure-relief valve in boro-silicate glass for withstanding highly-corrosive conditions. Two sizes, one for 5 lb. per square inch and the other for 30 lb. per square inch. For use with " Quickfit " chemical apparatus. Leaflet.

300-kV X-Ray Unit. SOLUS-SCHALL, LTD., 18 New Cavendish-street, London, W.1, constructional details of 300-kV constant-potential X-ray unit for laboratory and shop use. Suitable for radiography of specimens from light-alloy castings to 4-in. steel sections. Illustrated pamphlet.

Electrothermal Testing Apparatus. ELECTROTHERMAL ENGINEERING, LTD., 270 Neville-road, London, E.7. Units for Kjeldahl, Soxhlet and similar determinations; macro and micro ranges for Kjeldahl digestions. Illustrated leaflet with technical data and dimensions.

Face and Hand Dryer. SPIRAL TUBE AND COMPONENTS CO., LTD., Osmaston Park-road, Derby. " Air-towel " steam heated face and hand dryer. Two models for four and eight places, with separate control for each, and three types for steam ranging from 5 to 120 lb. per square inch. Bulletin B/5.

High-Output Ball Mill. STEELE AND COWLISHAW, LTD., Cooper-street, Hanley, Stoke-on-Trent. High-output " Smalls " department ball mill. Improved model with capacity of 10 gallons. Illustrated leaflet.

Roller Chains. RENOLD CHAINS, LTD., Wythenshawe, Manchester. Roller chains for suspension, support, thrusting, gripping and driving. Illustrated booklet of unusual applications and list of items available.

Electrostatic Separation. STURTEVANT ENGINEERING CO. LTD., Southern House, Cannon-street, London, E.C.4. Single and multi-stage machines for the electrostatic separation of minerals. Publication No. 7202 superseding earlier issues.

Emulsion Cleaner. THE PYRENE CO. LTD. (Metal Finishing Division), Great West-road, Brentford, Middlesex. " Pyroclean " No. 101, an emulsion-type degreasing agent for use in aqueous solution at 160 deg. F. Leaflet.

Water Treatment. FEEDWATER SPECIALISTS CO., St. Paul's -square, Liverpool, 3. Chemistry and operation of the lime-soda and base exchange processes. Publication No. 198.

PLASTICS ON VIEW

The third British Plastics Exhibition and Convention at Olympia, which opened on June 1, and closed on Saturday, June 11 was organised by the journal *British Plastics* in co-operation with the British Plastics Federation, and covered three main fields—finished products, plant and machinery, and raw materials. This year there were 120 exhibitors, and some 30 would-be exhibitors had to be turned away. For the next exhibition to be held in 1957, plans are being made for more accommodation and it is possible that the exhibition will be international instead of, as at present, confined to British and Dominion firms.

At the convention, 20 papers were presented in 12 sessions, covering polymer structure and polymers, expanded plastics, thermoplastics, extrusion, work study and productivity, injection moulding, patents, foundry resins, and glass-reinforced plastics. The papers and the discussions which followed them are to be published in a single volume, " Plastics Progress, 1955," in the autumn.

GLASS-REINFORCED PLASTICS

From the engineering point of view possibly the most significant development in the plastics industry within the last two years is the increasing application of glass-fibre reinforced plastics as structural materials not only in the aircraft industry but for boat-building and automobile bodies. Typical examples at Olympia were a complete sports-car body designed for fitting to any 1938–54 Ford 8–10 h.p. chassis, made by Martin Plastics (Maidstone) Limited, and shown on the stand of Bakelite Limited; and, among several small boats, the Moonfleet speed-boat shown by British Resin Products Limited. Tube Investments Limited, displayed a glass-fibre resin tube capable of withstanding pressures up to 5,000 lb. per square inch and temperatures of 120 deg. C. Other exhibits of this company illustrated the beneficial effects of high-energy radiation on many plastics materials, which are thereby converted from thermoplastic to thermoset structures, with marked changes in their solubility, swelling and melting characteristics.

The use of polythene and rigid polyvinyl chloride for ducting and plant in the chemical industries is now well established. Among the firms showing all-P.V.C. exhaust fans and pumps were Rediweld Limited, and British Geon Limited. The latter firm showed a scale model of a coal mine, illustrating a non-inflammable coal conveyor belt in Geon polyvinyl chloride. During the past seven years, all rubber belting in British coal mines has been replaced by P.V.C. belting, which, in addition to eliminating the fire hazard, has proved tougher and more serviceable.

For the first time the Canadian Government were exhibiting the products of 15 Canadian plastics firms. Among these exhibits a new flooring material that can be used for repairing concrete floors, Laticrete, made by the Nangatuck Chemicals Division of the Dominion Rubber Company, Limited, was of interest. Laticrete, it is claimed, combines the resilience and wearing qualities of rubber with the structural characteristics of concrete, to which it bonds readily.

VACUUM FORMING

Among the plant developments since the last exhibition may be mentioned the increasing use of vacuum forming processes, plant for which was displayed by the Projectile and Engineering Company Limited, Alfred Herbert Limited, and W. Edwards and Company (London) Limited. The latter are now making under licence from Hydro-Chemical, Switzerland, the Formvac range of machines; the example on view was a twin table machine with an effective moulding area of 40 in. by 60 in. on each table, and a maximum depth of draw of 22 in. for female moulds and 14 in. for male moulds. Other new equipment included improved vacuum-coating plants by Vacuum Industrial Applications Limited; a 3½-in. extruder built up on the Meccano principle, for ready dismantling and replacement, by Maniplastics, Limited; new plastics welders and a preheater shown by Radio Heaters Limited,

a new infra-red heating panel designed to avoid "streaking," exhibited by the General Electric Company Limited; and various injection-moulding machines, extension presses, mixing machines, etc. Lack of space forbids mention of many other interesting developments of this growing industry which are to be seen at Olympia.

CZECHOSLOVAK PLASTICS

Concurrently with the British Plastics exhibition, a smaller display was held at the showrooms of Slough Estates, 16 Berkeley-street, London, W.1, of Czechoslovak plastics made by Chemapol, Prague, which concluded on June 10. The materials on view included Silon polyamide moulding powders, a nylon-type material suitable for gears, bearings, etc.; Chemolite phenol-formaldehyde moulding powders, for housings, fancy goods, electrical components, etc.; rigid P.V.C. sheets and a thermoplastic vinyl-based sheet used for surgical appliances; and a new resin, DM 55, for photo-elastic analysis with good optical and mechanical properties.

* * *

"OIL PEOPLE"

Shell Film of an Industrial Family

The character of a great industry is formed by the people who serve it and live on its bounty; its setting is their home, whether a desert, swamp or the teaming deck of an ocean-going tanker. In fact, a great industry is in some senses a great family, with its members ranging through many continents, like the sons of Noah. The Royal Dutch/Shell family, for example, is truly international—250,000 sons and daughters, of every race and colour, all drawing their life from oil and taking root wherever it is found, processed or distributed. Their lives provide the subject of a new Shell film, "The Oilmen," which tells their story vivaciously, entertainingly and dramatically.

Oil men—and women—are all the people who make the industry work, from the girl who operates an adding machine to the man who "spuds in" a well, from the first mate on a tanker to the geologist's sample boy, from the geophysicist who prods the earth for untapped deposits to the catalytic-cracker Jack who makes them usable. But it is oil that all these people have in common, whether their home be Venezuela, Indonesia, Holland or Kuwait.

In photographing "The Oilmen," the camera has wandered into many remote places and has brought back a record of many different ways of living. It is a beautiful and exciting film, a film that will make many wish they were "oilmen"—at least for a while. In directing it, Denis Segaller has assembled a wide range of contrasting material, but cutting and continuity have created from it a single rhythmic narrative.

Possibly the most attractive passage is one in which oil men are shown at play, while as a background Muriel Smith sings to guitar accompaniment a creole song which is bound to be a hit. In this sequence, which is reminiscent perhaps of the American "Muscle Beach," a fierce-looking baseball pitcher tosses a ball, an Asiatic plays table tennis, a Dutchman catches fish, an Englishman tosses back a pint, and a whole world of sport and pastime is covered in the course of a song. The melody has been composed by James Stevens, whose evocative orchestral score for the remainder of the film unobtrusively conjures the mood of every place visited by the camera.

It is a little surprising that the film continues after this point, for the resolution of an oil man's life, if not its purpose, lies in his leisure; and after this climax the force of the final passage is to a great extent lost. But this is a minor criticism of an entirely successful picture. "The Oilmen," which runs for 37 minutes, has been made in both 35 mm. and 16 mm. gauges, and further information concerning its distribution may be obtained from the Shell Petroleum Company, Limited, Public Relations Department, 1 Kingsway, London, W.C.2.

Also released recently by Shell is another graceful film entitled "Proud Ships." It deals with tankers in general and the "Liparus" in particular, and contains some exciting storm photography. Its personal approach gives it the character of a seaman's tale and, like "The Oilmen," it has a fascinating musical score. Also in 16 mm. and 35 mm. gauges, it lasts for 24 minutes and may be borrowed from the Petroleum Films Bureau, 29 New Bond-street, London, W.1.

Incidentally a Shell film, "Back of Beyond," received the highest documentary award at the Venice Film Festival last year. The Shell Film Unit has now 170 films to its credit, of both an instructional and a general nature, and is soon to celebrate its 21st anniversary.

* * *

PLASTICS-DISC RECORDER

Accurate Indexing of Start and Finish

A disc-recorder called the "Agavox" recently produced by Svenska A.B. Gasaccumulator, Stockholm-Lidingö, Sweden, and marketed in this country by M. and L. Haycraft, Limited, St. Stephen's House, London, S.W.1, has as one of its most useful features an accurate method of indexing. The plastics recording discs each take 12 minutes' dictation, and are easily inserted into the machine; when a new disc is started an index strip is also inserted, which records the exact point of start of dictation, end of each letter, and all corrections. Record, playback and listen can all be controlled from the microphone, which can act as a speaker; there is also a loudspeaker on the machine. A light-weight earphone and foot-control switch are available for the typist. Recordings can be erased from the disc either by speaking over a previous recording or by pushing a button which clears the complete disc immediately. An adjustable voltage control enables the machine to be used on any voltage in the 100-volt range or the 200-volt range. Dimensions of the recorder are 12 in. long by 9 in. deep by 5½ in. high, and it weighs 14 lb.

* * *

EXTRACTING SULPHUR IMPURITIES

Continuous Process at Oil Refinery

A plant to remove sulphur impurities from oil went into operation last April at the Stanlow refinery of the Shell Petroleum Company, Limited, St. Helen's Court, Great St. Helen's, London, E.C.3. The plant, developed by the Royal Dutch/Shell Group's research organisation at Amsterdam, will increase the supply of high-quality fuels for Diesel engines and farm tractors, and will also make a certain amount of 100-octane motor spirit component. The hydro-desulphurisation process operates on a trickle technique, so-called because the oil to be desulphurised is contacted with hydrogen and made to trickle over a cobalt-molybdenum-alumina catalyst in a reactor. The hydrogen converts the sulphur into hydrogen sulphide which is separated from the oil and is then itself converted to pure elementary sulphur. When processing light cat-cracked cycle oil the reactor products are split into a highly aromatic heavy gasoline fraction, a 220 to 260 deg. C. fraction and, as a main product, a bottom fraction boiling above 260 deg. C. The main product contains 0·3 per cent. by weight of sulphur. Overall desulphurisation of 90 per cent. or more has been obtained for daily feed rates of 5,000 and 7,000 barrels.

FUEL EFFICIENCY PAYS

National Industrial Fuel Efficiency Service Surveys Progress

One of the major limitations on productivity in Great Britain is the permanent fuel deficiency to which this country is subject. For this reason, as observed in the First Progress Survey of the National Industrial Fuel Efficiency Service, "fuel efficiency must be regarded as an aid to productivity." Fuel saved is fuel available for other purposes, and it is estimated that on present usage a cumulative saving of one million tons of coal each year can be achieved. It is with the object of promoting economy of this kind that N.I.F.E.S. was established.

"FOUR-WAY SERVICE"

The National Industrial Fuel Efficiency Service was incorporated on December 2, 1953, as a non-profit-making company under the sponsorship of the British Productivity Council; its purpose was to take over and expand the work of the Fuel Efficiency Department of the Ministry of Fuel and Power and it began operations on May 1, 1954. The company can draw a maximum annual contribution of £250,000 from the National Coal Board and up to £100,000 from the Gas Council and the Central Electricity Authority, for a period of five years from April 1, 1954. In spite of the drastic change from a Government department to an independent concern, N.I.F.E.S. made rapid progress and after eleven months of activity has now nine area offices and six sub-offices, scattered over Great Britain and Northern Ireland. Incidentally, although during this time the number of engineers on its staff has risen from 126 to 151, the number of non-technical employees, of which there are now 67, has remained approximately constant.

One of the first duties of the new organisation was to publicise its activities, and a brochure entitled "The Four-Way Service of N.I.F.E.S." was prepared, describing four types of service considered most likely to meet industrial needs. These were: 1. A first aid service to advise on "trouble shooting"; 2. operational improvement, or tuning a given plant to maximum efficiency; 3. inspection in detail or an assessment of present efficiency with a view to possible plant alteration; and 4. full heat and power survey, using a mobile test unit and providing a complete heat balance. In this way the requirements of both large firms and small could be satisfied. In addition, regular and multiple service agreements were established; the first for firms desiring repeated checks on plants, and the latter for such organisations as local authorities with numerous installations distributed over a wide area.

LOANS FOR ADAPTING PLANT

Other activities of N.I.F.E.S. include the training of operators and the provision of refresher courses for works engineers, and the preparation of fuel-efficiency propaganda. N.I.F.E.S. also serves as technical adviser on the application of Government loans for adapting existing plant or buildings in the interest of fuel economy. Loans are interest free for two years, while repayment may be spread over a maximum period

SAVINGS OBTAINABLE IN BOILER PLANTS

Improvement	Saving as per cent. of total fuel used
Use of feed-pump exhaust for feed heating, or reconditioning of feed pump	2—7
Replacement of steam jets for fire-bar cooling	2—8
Overhaul of safety valves to prevent blowing	Up to 8
Recovery of heat from blowdown	,, 5
Improved firing	,, 20
Installation of economisers	,, 12
Descaling of boilers	,, 7
Reduction of air infiltration	,, 3
Prevention of internal leakage in brickwork	,, 7
Avoidance of by-passing of economisers	,, 7
Insulation and covering of feed and storage tanks	,, 4

of 20 years, and during the eleven-month period previously mentioned 139 applications were approved for a total of £815,314.

The response to the introduction of the "four-way" service is indicated by the number of firms which between May 1, 1954 and March 31, 1955, made use of it. First-aid service was provided for 5,525 factories and non-industrial establishments, and 327 heat and power surveys were completed. A guide to the kind of recommendations made, together with the corresponding savings, are given in the table on page 755. Other factors considered have been smoke and grit emission, back-pressure generation of power and the use of fuel oil.

Examples of the economies which can be achieved in industry are given in the N.I.F.E.S. First Progress Survey. A large paper mill, for instance, will save 4,795 tons of fuel a year—32 per cent. of its total consumption—by replacement of boiler steam jets with a forced-draught fan, recovery of condensate from paper machines, improving turbine performance and use of an electric motor to drive the beaters; while a small paper mill can save 515 tons (25·7 per cent. of its annual fuel consumption) without any capital expenditure. A textile firm will save 190 tons (42·5 per cent.) by repairs to boiler brickwork and an economiser, and by effectively insulating the roof of the works; and a laundry by properly lagging its steam mains can save 76 tons of coal per year (6·7 per cent.).

The Progress Survey also covers N.I.F.E.S. co-operation with other organisations, research and development, directors' report and a statement of accounts, in addition to treating more extensively the topics dealt with in this article. A list of area engineers is also given together with numerous tables summarising the work completed during the eleven months surveyed.

FUEL ECONOMY AND PRODUCTIVITY

It was impossible, however, to assess the actual improvement in fuel efficiency achieved, for even as fuel is saved in one direction it is demanded in another. For example, on account of increased productivity, industry required four million tons of coal more in 1954–5 than in 1953–4, and will need still more this year. Attention is drawn to the savings particular firms can make and it is emphasised that an economy in an industry where the fuel bills are only a small proportion of the total manufacturing costs is just as valid in terms of cash as in an industry where fuel is the major consideration. The real test of N.I.F.E.S. is the extent to which industry calls on its engineers for advice. In these first eleven months it has advised one in six of all consumers of over 100 tons a year and the corresponding aggregate annual fuel consumption involved is 9 million tons.

The First Progress Survey with Report and Accounts of N.I.F.E.S. for the period to March 31, 1955, may be obtained from the Service's offices at 71, Grosvenor-street, London, W.1.

HEAT AND CHEMICAL RECOVERY IN PAPER MILL PROCESS

BOILER FIRED WITH RECOVERED LIQUOR WASTE

As already described in ENGINEERING* some of the steam consumed in the pulp and paper mill of the Bowater Paper Corporation at Calhoun, on the Hiwassee River in Eastern Tennessee, is obtained from a so-called recovery boiler which is fired with "black liquor" recovered from the chemical pulping process. The furnace of this boiler is designed to handle 950,000 lb. per day of black liquor solids—an amount which results from a production of approximately 320 tons per day of chemical pulp. The rated steam output of the boiler is 123,200 lb. per hour at a pressure of 875 lb. per square inch and a temperature of 825 deg. F., the feedwater temperature being 280 deg. F.

The employment of this black liquor for steam raising has given rise to some interesting design and operating problems, both in the boiler itself and in the associated preparation plant. These are dealt with in more detail below.

THE CHEMICAL PROCESS

One of the products of the Calhoun mill is sulphate chemical pulp, which is made by cooking wood chips in digesters with a liquor of which the active chemicals are sodium hydroxide and sodium sulphide. This cooking action separates the lignin, or binder material, from the cellulose and the cellulose, after being separated out from the residual cooking liquor, provides the pulp for paper manufacture. The residual cooking liquor, which is known as weak black liquor, contains substantially all the chemical fed to the digesters and, in addition, about half the organic matter in the wood. The economy of the sulphate process depends on recovery and re-use of the chemical. One of the steps in this recovery is the firing of the liquor in a suitable furnace. The black liquor, after adequate preparation, provides the fuel for the recovery furnace where burning of the organic matter generates heat for smelting the chemical and the production of steam. The smelted chemical is reclaimed and after further treatment is re-used as cooking liquor. The recovery unit thus performs a vital function in the chemical recovery cycle in addition to its function of steam-raising.

* Vol. 178, page 317 (1954).

RECOVERY CYCLE

Before outlining some of the design and operating features of the Calhoun recovery installation, a few words may be said about the recovery process in general.

The major steps in the chemical recovery process are: the separation of pulp and liquor; the evaporation of liquor to a burnable concentration; the burning of the liquor with recovery of chemical and heat, and the treatment to return the chemical to its original form.

The separation of pulp and liquor is generally performed on counter-flow vacuum washers, which are designed and operated to wash the liquor from the pulp with minimum addition of water. Weak black liquor is delivered from the washers to the weak liquor storage tanks at a concentration of from 14 to 20 per cent. solids and a temperature of about 185 deg. F.

The liquor as it comes from the washers is too dilute to support its own combustion and, before burning, most of the water associated with the liquor solids is removed by evaporation. Evaporation to optimum firing concentration is generally performed in two stages. The first of these is carried out in multiple-effect evaporators operating on live steam and the second stage in direct-contact evaporators using flue gas from the recovery unit as the evaporating medium.

It is desirable for reasons of heat economy to carry out the major portion of the evaporation in multiple-effect evaporators where one pound of steam will evaporate several pounds of water, the ratio depending on the number of evaporator effects employed. As black liquor beomes concentrated its viscosity increases sharply and at about 50-55 per cent. solids concentration it becomes impractical to continue the evaporation in conventional multiple-effect evaporators. At this point, the liquor is withdrawn and evaporation to the firing concentration of 60-70 per cent. solids is performed in the direct contact evaporator.

BURNING AND CHEMICAL RE-GENERATION

Conversion of the chemical in the black liquor to fresh cooking liquor is performed partly in the recovery unit and partly at a subsequent stage. During the digestion process the active cooking chemicals undergo change. In reacting with and dissolving the non-cellulose wood materials, the sodium hydroxide forms complex organic sodium compounds. The sodium sulphide reacts similarly, and in addition forms various organic sulphur compounds. During the burning operation, the chemicals are smelted out, the sodium present reacting to form sodium carbonate and sodium sulphide. The sodium originally present as sodium sulphate is, by proper control of the air supply to the furnace, reduced by hot carbon in the fuel bed to sodium sulphide.

Before the liquor is fired to the furnace two additions of chemical are made. To make up the unavoidable losses of chemical in the pulping and recovery process, salt cake (sodium sulphate) is added to the black liquor. The flue gases resulting from the combustion of black liquor contain chemical fumes and entrained particles. Some of the particles may be caught in hoppers and in the direct contact evaporator. The fumes, however, must be separated from the flue gas by other means, usually by electrostatic precipitators. The separated chemical, which consists of sodium sulphate and sodium carbonate, is then added to the black liquor before it is sprayed into the furnace.

The smelted chemicals are drawn off continuously from the furnace through water-cooled spouts into a dissolving tank where they are dissolved in wash water from the causticising room to form green liquor. The green liquor is re-pumped to the causticising room where lime $Ca(OH)_2$ is added. The lime reacts with the sodium carbonate to form sodium hydroxide, which with the sodium sulphide forms the active ingredients of the cooking liquor.

DESIGN AND OPERATION

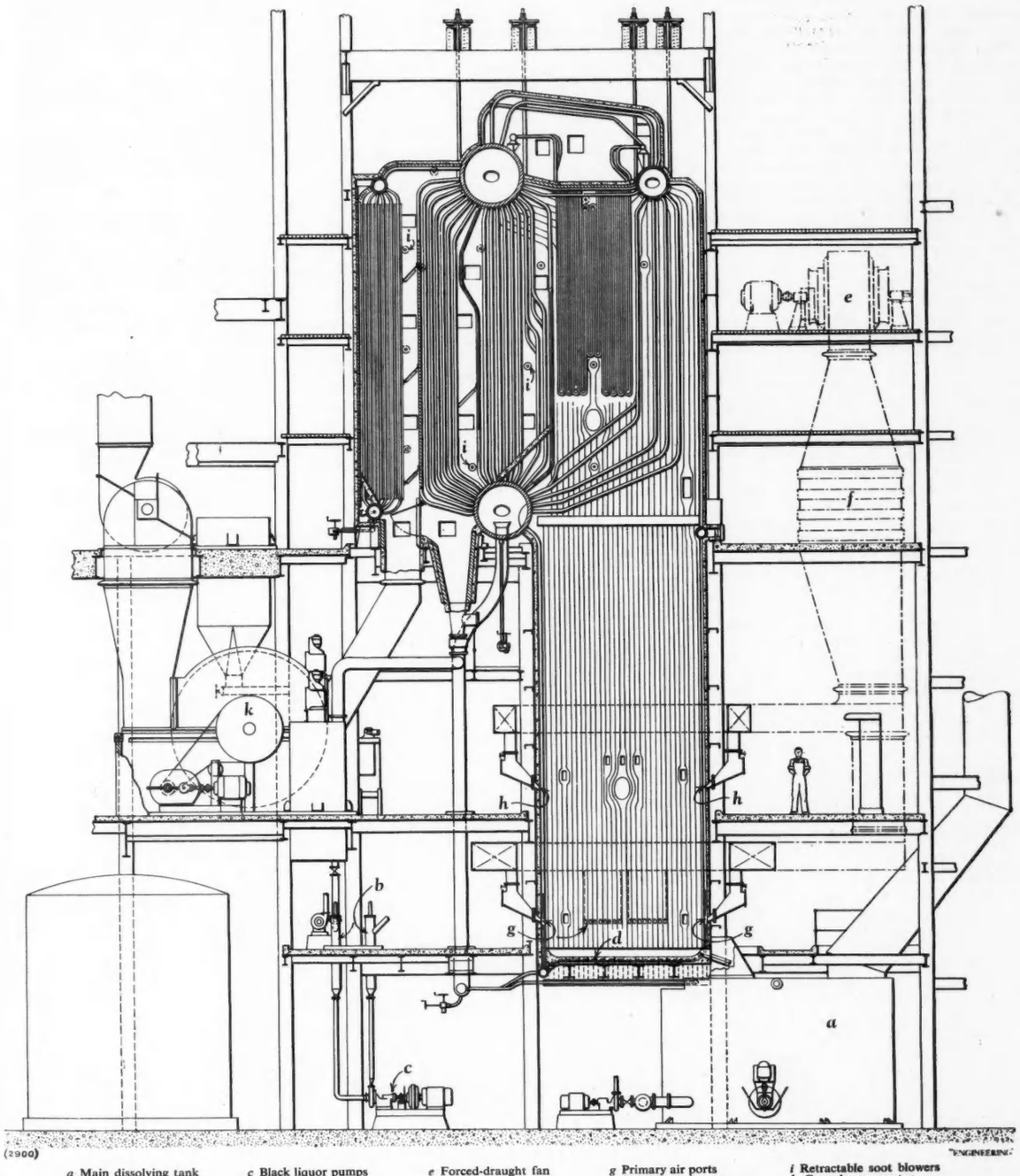
In essence, efficient operation of the recovery cycle consists of washing the black liquor from the pulp with as little dilution as possible, evaporating the liquor to a readily combustible condition with a minumum consumption of heat, burning with a maximum recovery of heat and chemicals, conversion of a maximum percentage of sodium sulphate to sulphide and the highest possible conversion of sodium carbonate to hydroxide. Properly designed recovery equipment is a requisite to efficient operation. Not only must the equipment be arranged to achieve certain efficiencies, but the desired efficiency must be obtainable for long periods without interruption to the pulp making process. The physical and chemical characteristics of the black liquor must be known and considered at every stage of design and operation.

Some of the details of design and operation of the Calhoun evaporation and recovery equipment are discussed below.

MULTIPLE-EFFECT EVAPORATION

The evaporators installed at Calhoun were supplied by Goslin-Birmingham Manufacturing Company, Incorporated, Birmingham, Alabama, and are of the long-tube type. Six bodies are employed and are arranged to operate as a sextuple-effect unit. This unit is designed to evaporate 173,000 lb. of water per hour from 232,000 lb. of liquor per hour at 180 deg. F. and containing 14 per cent. of solids. The output is 59,000 lb. per hour and contains 55 per cent. of solids.

Black liquor from the washers flows to the weak liquor tanks with a concentration of about 15 per cent. of solids at a temperature of 180 deg. F. From the storage tanks the liquor is pumped directly to the multiple-effect evaporators where the solids concentration is raised by evaporation to 45 to 50 per cent. The liquor is



Sectional elevation of the 123,200 lb. per hour boiler at Bowater's Calhoun paper mills. It is fired by black liquor solids recovered from the chemical pulping process used in the manufacture of paper.

then pumped to the heavy liquor storage tanks at a temperature of about 225 deg. F.

Steam is supplied only to the first effect, the consumption of the designed evaporation rate being 34,500 lb. per hour at a pressure of 35 lb. per square inch. Thus, 5·01 lb. of water are evaporated for each pound of steam consumed. The steam condensate from the first effect is uncontaminated and is returned to the boiler feedwater system. Vapours evaporated from the liquor in the first effect serve as the heating and evaporating media for liquor in the second effect. Second-effect vapours serve as the heating medium for the liquor in the third effect, and so on through to the sixth effect. Vapours from the sixth effect are condensed by a surface condenser which maintains a vacuum of about 25 in. of mercury on the sixth effect. The condenser cooling water is re-used in the pulp mill. The second, third, fourth, fifth and sixth effects are provided with a flash-condensate removal system. All vapour condensate is collected and removed from the evaporator through one pump. Since the vapour condensate is contaminated, it is discharged into a sewer.

The liquor piping is arranged for divided liquor feed to the fifth and sixth effects. The liquor is pumped from these effects to the fourth effect, then to the third effect, then to the second effect and thence to the first effect. The liquor passages in the first effect are divided, so that the liquor makes two passes. From the first effect, the liquor flows to a flash tank which has a vapour connection into the third-effect vapour head. From the flash tank the liquor is pumped to the heavy liquor storage tank.

BLACK LIQUOR CHARACTERISTICS

Black liquor has several important characteristics which must be considered in the design and operation of the evaporators. These include the tendency of the liquor to foam and scale, its viscosity and soap content of the liquor and its corrosive nature.

Black liquor tends to foam, particularly at low solid concentrations. Unless the design and operation are satisfactory, severe intermittent liquor losses may occur due to liquor carry-over. The Calhoun evaporator heads are provided with dished deflectors under which the liquor impinges as it issues from the tubes;

cyclone-type "catchalls" are also provided through which the vapour passes after leaving each effect. Liquor droplets are separated out and returned to the liquor side of the evaporator.

As black liquor becomes very viscous at high concentrations care must be taken in operation to insure that this condition does not occur and cause scaling or reduction in the rate of heat transfer and capacity. When pine wood is pulped, the fatty and resin acids present dissolve in the cooking liquor as sodium soaps. If the soap is not separated from the liquor, the evaporator tubes will foul. The soaps are more or less insoluble in the black liquor and tend to separate and float to the surface. Some separation occurs in the weak liquor tanks. This is hastened as the concentration of the liquor increases and it is common practice to withdraw it from the evaporator effect where the concentration is such that maximum soap removal is obtained. At Calhoun, the liquor leaving the fourth effect is pumped to a settling tank where the soap rises and is skimmed off. The skimmed hot liquor is returned to the third effect.

There is a tendency toward formation of a coating of inorganic matter on the surface of the liquor side of the evaporator tubes, particularly in the high-temperature effects. This deposit greatly decreases the rate of heat transfer. It is, however, generally soluble in water and it is the practice to boil out the evaporator with water at intervals of a week or two.

Black liquor corrosion may be severe when the liquor temperature is high, particularly if that high temperature is accompanied by conditions causing erosion. The use of stainless steel becomes important in the high-density, high-temperature effects, and in pumps and fittings. In the Calhoun evaporators, the first and second-effect heating elements are fabricated from a low carbon stainless steel containing 18 per cent. chromium and 8 per cent. nickel. The lower halves of the vapour heads of these two effects are clad with the same material. All the pumps are also constructed of stainless steel and the valves are trimmed with it.

As an aid to smooth and efficient operation, the evaporators are equipped to indicate, record and control important variables in the evaporation process. After starting up by hand, the liquor feed may be set at the desired flow rate. The automatic controls will then maintain this rate and will control the pressure of steam fed to the first effect so that the liquor delivered from the evaporator is of the desired density.

SOME BOILER DESIGN REQUIREMENTS

Before describing the recovery furnace and boiler at Calhoun, a few words may be said generally about combustion of black liquor and the design requirements of recovery units.

Compared with the common steam-raising fuels, black liquor is a poor fuel, with high moisture and ash contents, and low ash-fusion, temperature. A typical as-fired analysis of black liquor with added salt cake make-up and precipitator returns is as follows: moisture, 32 per cent.; carbon, 24 per cent.; hydrogen, 2·2 per cent.; sulphur, 2·7 per cent.; oxygen and nitrogen, 8·1 per cent.; and ash, 31 per cent.; the higher calorific value being 4,300 B.Th.U. per lb.

The combustion conditions maintained in the furnace are governed by the chemical recovery requirements. The principal zone of chemical recovery is on the hearth of the furnace. Here, the residual carbon in the black liquor is burned out, the inorganic sodium salts are smelted and flow over the hearth to the front of the unit where they are discharged through water-cooled spouts. In the char bed which forms on the hearth, the sodium sulphate, in the presence of carbon and a highly-reducing atmosphere, is reduced to sodium sulphide.

The temperatures in the hearth zone must be maintained so that the combustion is self-sustaining and be high enough for the smelt to flow freely from the spouts. High temperatures are to be avoided. Even at the minimum temperature at which stable ignition of the char can be maintained there is some sublimation of sodium salts from the bed. These vapourised salts are carried from the furnace with the flue gas and as the latter is cooled in passing through the boiler surfaces, some of the sublimed salts deposit on the heat-absorption surfaces. The liquor as introduced to the furnace contains about 35 per cent. moisture and before combustion on the hearth can take place, this must be removed. Consequently the recovery unit must be designed to provide for satisfactory drying of the liquor before it is deposited on the hearth.

One of the major design requirements is that of high availability. Probably the biggest problem that must be overcome in this respect is that of keeping the gas passages from fouling and restricting the flow of flue gas. Furnaces are designed and operated to minimise the quantity of sublimed and mechanically entrained particles in the gases leaving the furnace; and the boiler heat absorbing surfaces are arranged so that the gas temperature and flow conditions result in a minimum deposition of chemical solids. Surfaces are arranged to facilitate the removal of the solids that are deposited and their return to the chemical recovery cycle.

RECOVERY UNIT

The Calhoun recovery unit was supplied by Combustion-Engineering Superheater Company, Incorporated, New York, who also supplied the cascade type direct-contact evaporator, fans, pumps, heaters, tanks and controls. To recover about 95 per cent. of the chemical fumes in the flue gases leaving the unit an electrostatic precipitator is employed. A general arrangement of the boiler and of the some of the auxilliary equipment of the recovery plant is given on the previous page.

From a heavy liquor storage tank, which receives liquor from a multiple-effect evaporators, the liquor is pumped to dust hoppers located beneath the precipitator. The precipitated dust is dissolved in the black liquor, which then flows by gravity to a chemical ash tank. Liquor from the chemical ash tank is circulated through the bottom of the boiler ash hopper to pick up ash dislodged from the boiler surfaces and then back to the chemical ash tank. From the chemical ash tank the liquor overflows into the direct contact evaporator where it is concentrated suitable for firing. From the evaporator the liquor flows to the salt cake mixing tank where the salt cake make-up is added and mixed in with the liquor. From the salt cake mixing tank the liquor flows through a direct steam heater which increases its temperature and reduces its viscosity before entering the black liquor feed pump. From the feed pump the liquor flows through a second direct steam heater which further reduces the viscosity to the optimum viscosity and temperature for spraying into the furnace.

As an aid to combustion, preheated air is used. This is supplied by a conventional forced-draught fan to a steam coil air heater using steam at 140 lb. per square inch and 40 lb. per square inch; the air temperature at the air heater outlet being about 300 deg. F. Primary air is supplied just above the furnace hearth, secondary air being admitted higher up.

Black liquor is introduced to the furnace through six spray nozzles, three on each side of the unit. These nozzles are located about 18 ft. above the hearth. The liquor is sprayed at a pressure of about 20 lb. per square inch through nozzles designed to form coarse droplets which dry as they descend through the rising stream of hot gases from the hearth. These nozzles are mounted on rocker shafts and are oscillated at six strokes per minute through an angle of about 15 deg. downward from horizontal. Some degree of control of droplet size is obtained by varying the temperature and pressure of the liquor and the number of nozzles in use.

The dried char particles fall to the hearth where a cone-shaped bed forms. Primary air is admitted through a series of 4 in. by 2 in. ports in a belt approximately 3 ft. above the hearth. To maintain the atmosphere necessary to carry out the reduction of the salt cake, a deficiency of air is admitted through the primary ports. The remainder which is necessary to complete combustion is supplied through a secondary belt of ports located about 3 ft. below the spray nozzle elevation.

The furnace is completely water-cooled. The furnace walls consist of bare tubes with welded fins along the wall centreline. The hearth consists of finned water-cooled tubes which have only a thin covering of chrome ore refractory. The hearth is not inclined. The two smelt spouts, at the front of the furnace, are located about 3 in. above the hearth with the object of providing a solidified layer of smelt which will protect the hearth from erosion by the molten material flowing to the spouts.

BOILER DESIGN

The boiler is of the tri-drum type with the superheater located at the top and to the rear of the furnace. The furnace gases traverse screen tube surfaces before reaching the superheater. Smelt and ash deposits dislodged from screen and superheater fall directly into the char bed on the hearth.

The superheater is of the platen type in which the tubes in each element, or platen, have no "backspacing." The elements are spaced across the boiler width on wide centres so that the gases flow between them. The object of this design is to present a flat surface on which the ash deposit will be a minimum and from which it may be easily dislodged. Gases from the furnace flow upward across the first pass or screen surface, across the superheater, downward through the second pass, upward through the third pass, and downward through the economixer to the cascade type direct contact evaporator.

The superheater, boiler and economiser are equipped with automatic soot blowers. Retractable steam blowers are used in the high temperature zones and non-retractable air-blast units are used in the cooler passes. There are twelve retractable blowers operating at approximately 275 lb. per square inch steam pressure and sixteen air-blast blowers operating at approximately 325 lb. per square inch air pressure. All the blowers are automatically operated in sequence under the control of a master controller which is installed on the operating floor.

The unit is equipped with a number of pressure and temperature indicators and recorders, and with gauges showing the draught in each boiler pass. There are no automatic combustion controls other than a furnace draught controller. The quantity of combustion air is regulated by adjusting the forced draught fan damper by remote control. The furnace draught controller automatically varies the speed of the induced draught fan. This fan is driven by a constant speed motor through a variable-speed hydraulic coupling.

After flowing through the conventional two drum vertical tube economiser, the flue gases pass through the evaporator in which the liquor is concentrated. Here, the flue gas flows across wheel surfaces wetted with the black liquor which is to be evaporated. The wheels and flue gas are enclosed in a metal casing, the lower part containing the black liquor and the upper part forming the gas passage. The slowly rotating wheels are fitted with axially arranged tubes which dip into the black liquor to within 2 or 3 ft. of the wheel shaft. The Calhoun evaporator consists of two wheels 14 ft. in diameter which are arranged in parallel, the tubes being 9 ft. 6 in. long. Each wheel is driven separately through reduction gearing at 4·65 r.p.m. by a 40-h.p. motor. The temperature of the flue gas is reduced from approximately 650 deg. to 300 deg. in passing through the cascade.

From the cascade, the flue gas passes through the induced draught fan and through the electrostatic precipitator before exhausting to the stacks.

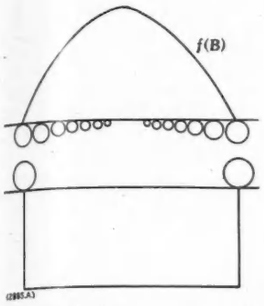


Fig. 1 Winding arrangement of salient-pole synchronous machine with gap of unit permeance.

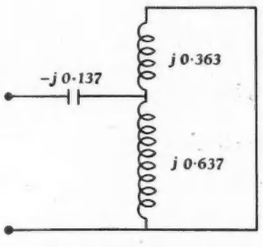


Fig. 2 Equivalent circuit of motor with voltage applied to stator winding and rotor winding short-circuited.

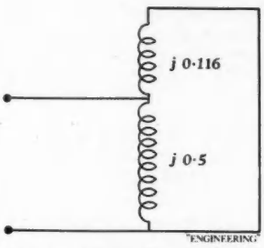


Fig. 3 Alternative equivalent circuit of motor when stator turns are $\frac{4}{\pi}$ times rotor turns.

ASYNCHRONOUS PERFORMANCE OF SALIENT-POLE SYNCHRONOUS MACHINES

SOLUTION BY NETWORK ANALYSER

By D. J. Miller, B.SC.(ENG.), A.M.I.E.E.*

In the majority of drives for which a synchronous motor is employed, the motor is only required to run asynchronously during the starting period. It can usually be started up under light load conditions, and the starting performance is thus of only secondary importance. Furthermore in order to limit the low power-factor starting current, the motor is usually supplied at a reduced voltage at starting by some form of tapped auto-transformer or reactor. Thus a limited control of the starting performance can be obtained at small extra cost by supplying a spare tap position on either side of the starting voltage tap.

For certain applications, however, the asynchronous performance becomes the governing factor in the design. An example of this is in the application of asynchronous motors to ship propulsion when, in changing from " full ahead " to " full astern ", the motor, while running asynchronously, may be called upon to deliver torques in excess of full load torque. In addition synchronous motors are frequently employed for large horse-power drives where high starting torques must be combined with good synchronous overload capacity and power factor. Such motors are normally designed for direct-on-line starting, and a special design of damper or starting winding is employed. The damper bars are so shaped as to magnify the normal skin effect, and must be so designed that the ratio of torque to stator current is a maximum consistent with adequate heat dissipation throughout the starting period, or at any speed at which the motor may be required to run asynchronously. When running asynchronously, the field excitation must of course be removed and the circuit completed, preferably through an external resistance.

This article outlines the theory governing the asynchronous performance of such motors, and illustrates it by examples taken from the design calculations for a 1,600-h.p., 3·3-kV, 1,000-r.p.m. synchronous motor designed for direct-on-line starting.

MAGNETICALLY-COUPLED DISTRIBUTED WINDINGS

The concept of mutual and leakage reactances of the two windings of a transformer is a familiar one to electrical engineers. The mechanism in a machine is similar, but it is complicated by the facts that the distribution of the flux is affected by the varying reluctance of the air gap and that, owing to the distributed nature of some of the windings, the calculation of the effective flux linkages is rather less straightforward.

Fig. 1 shows two coils separated by a gap of unit permeance. Each coil has unit total turns, the stator winding being sinusoidally distributed and the rotor winding being a full pitch concentrated winding.

Considering the flux linkage of any flux-density wave $f(B)$ with the sinusoidally distributed winding, the total flux-turns (pole pitch taken as unity)

$$= \frac{1}{\pi}\int_0^{\pi} f(B) \times \int \cos \partial\theta \, \partial\theta,$$

which, integrating and expressing $f(B)$ as a Fourier series,

$$= \frac{1}{\pi}\int_0^{\pi} \sin\theta \{B_1 \sin\theta + B_1' \cos\theta + B_2 \sin 2\theta + B_2' \cos\theta + \ldots\} \partial\theta$$

$$= \frac{1}{\pi}\int_0^{\pi} B_1 \sin^2\theta \, d\theta = B_1.$$

Therefore, only the fundamental component of the air gap flux wave is effective in inducing voltage in a sinusoidally distributed winding.

This expression can be used to derive the voltage and current relationships that define the equivalent circuit for the winding arrangement shown in Fig. 1. The winding flux linkages are, with stator winding,

$$\frac{i_s}{2} + i_r \frac{4}{\pi}\frac{1}{2} = e_s = \text{stator voltage},$$

and with rotor winding,

$$\frac{2}{\pi} i_s + i_r = e_r = \text{rotor voltage}.$$

To obtain the reactive elements of the equivalent circuit let i_s and i_r equal zero in turn:

if $i_s = 0$, then $e_r = i_r \times 1$ and $e_s = i_r \times \frac{2}{\pi}$,

or if $i_r = 0$, then $e_s = i_s \times \frac{1}{2}$ and $e_r = i_s \times \frac{2}{\pi}$.

For the case when voltage is applied to the stator winding and the rotor winding is short-circuited, these relations give the equivalent circuit shown in Fig. 2. If, however, the number of stator turns had been equal to $4/\pi$ times the number of rotor turns, the comparable equations would have yielded the equivalent circuit shown in Fig. 3, which is far simpler. The terminal reactances of this circuit are identical with those given by Fig. 2, the effect being merely (as it is termed in transformer engineering) to put the primary and secondary reactances on the same base.

While each phase winding on the armature of a synchronous machine is not strictly sinusoidally distributed, it can be regarded as such without much error, particularly when a chorded winding is used in conjunction with a large number of slots per pole. Adjustment to the machine impedances worked out on this basis can, if required, be carried out at a later stage to take account of the departure of the windings from the true sinusoidal distribution.

As is well known, three-phase currents flowing in the armature winding produce a sine wave of air-gap magneto-motive force rotating at fundamental frequency. This wave of magneto-motive force could equally well be produced by currents flowing in two windings rotating at the speed of the rotor and located at right angles to each other in the direct and quadrature axes. The frequency of these equivalent currents would be dependent upon the slip of the rotor with respect to the applied fundamental frequency, being unidirectional at synchronous speed. This concept is much used in synchronous machine analysis, the performance of the machine being deduced in terms of the equivalent axis currents, which are then combined to produce the true armature phase currents.

By this means the comparatively complicated arrangement of the armature windings can be resolved into two equivalent sinusoidally distributed winding arrangements as illustrated in Fig. 1, one for the direct and one for the quadrature axis.

CURRENT AND TORQUE RELATIONSHIPS

For convenience and ease of manipulation, all quantities are expressed in " per unit " based on the machine rating when the magneto-motive force equals the current, the flux equals the current multiplied by the impedance, and the voltage the flux multiplied by the frequency.

In general, the air-gap magneto-motive forces in the direct and quadrature axes of a salient pole machine running at slip S, will consist of unequal waves pulsating sinusoidally with time at slip frequency. These two standing waves (with respect to the rotor) can be replaced as far as induced voltages are concerned by two travelling waves of constant but different magnitudes travelling at slip speed relative to the rotor, the one in a forward and the other in a backward

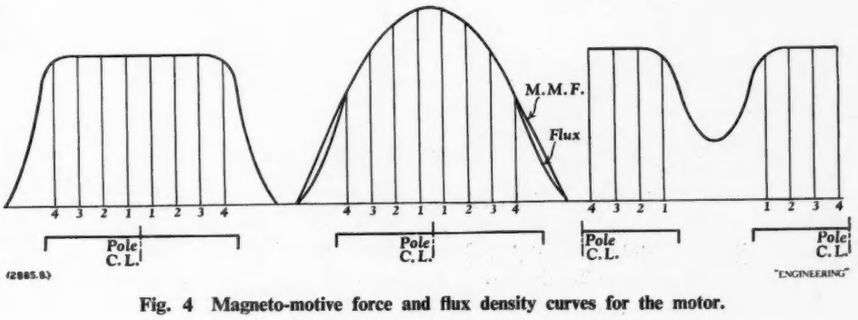


Fig. 4 Magneto-motive force and flux density curves for the motor.

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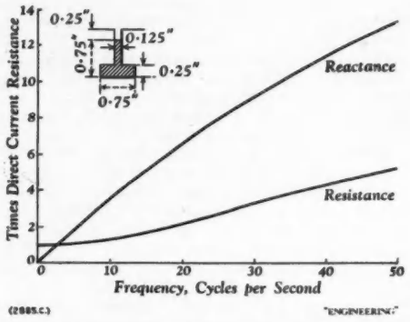


Fig. 5 Cross-section of damper bar, and variation of its resistance and reactance with frequency shown as functions of the direct current resistance.

direction. Since the rotor is moving at a speed of (1 − S), the velocities of the travelling waves relative to the armature will be

$1 - S + S = 1$ (forward component)

and

$1 - S - S = 1 - 2S$ (backward component),

and the magnitudes of the magneto-motive forces will be given vectorially by

$M_f = \frac{1}{2}(M_d + M_q)$, and $M_b = \frac{1}{2}(M_d - M_q)$,

or in per unit

$$i_f = \tfrac{1}{2}(i_d + i_q), \quad \text{and } i_b = \tfrac{1}{2}(i_d - i_q) \qquad (1)$$

Referring to Fig. 3, which is the simple equivalent circuit for the direct axis of a machine with only one rotor circuit in the direct axis, the stator and rotor quantities have been reduced to the same base and the stator leakage reactance neglected. Then the flux existing in the air gap is given by

$$(A\,T_{stator} - A\,T_{rotor}) \times \text{permeance of gap},$$

or

$$\phi_d = \frac{e_d}{f} = (i_d - i_r)\,x_{ad} = i_d\,Z_{ad}(p), \qquad (2)$$

where $Z_{ad}(p)$ is the operational impedance of the circuit at the particular slip considered, or in this case, since we are dealing with steady state values, the impedance of the circuit as viewed from the stator terminals.

The forward and backward rotating components of stator current when multiplied by their appropriate operational impedance, as in equation 2, will each give rise to pulsating fluxes in both the direct and quadrature axes. These fluxes can then be resolved, as were the magneto-motive forces, into two constant-magnitude travelling waves inducing constant-amplitude sinusoidal voltages in the stator winding, i.e. the forward voltage

$$e_f = \phi_f \times f = \left[i_f \frac{Z_{ad}(p) + Z_{aq}(p)}{2} + i_b \frac{Z_{ad}(p) - Z_{aq}(p)}{2}\right] \times 1.$$

and the backward voltage

$$e_b = \phi_b \times f = \left[i_f \frac{Z_{ad}(p) - Z_{aq}(p)}{2} + i_b \frac{Z_{ad}(p) + Z_{aq}(p)}{2}\right] \times (1 - 2S). \qquad (3)$$

Writing

$$Z_a S(p) = \frac{Z_{ad}(p) + Z_{aq}(p)}{2},$$

and

$$Z_a D(p) = \frac{Z_{ad}(p) - Z_{aq}(p)}{2},$$

and taking account of the voltage drops in the stator resistance and leakage reactance, the following equations can be written down for the terminal voltage :

$$V_f = 1 = i_f Z_a S(p) + i_b Z_a D(p) + i_f(R_1 + jX_1),$$

and

$$V_b = 0 = \{i_f Z_a D(p) + i_b Z_a S(p) + j i_b X_1\}(1 - 2S) + i_b R_1. \qquad (4)$$

In writing $V_f = 1$ and $V_b = 0$ it is assumed that the machine is connected to an infinite busbar of zero negative sequence impedance.

Equation (4) can be solved to give i_f and i_b, when, in agreement with classical induction motor theory, the average torque generated at any speed (1 − S) is given in per unit of the kilovoltampere rating of the machine by the average power crossing the air gap, i.e.,

$$T_{av} = e_f i_f \cos\theta - i_f^2 R_1 - i_b^2 \frac{R}{1 - 2S_1}. \qquad (5)$$

DERIVATION OF EQUIVALENT AXIS CIRCUITS

The basis of the method is that if the direct and quadrature axis circuits are arranged symmetrically there can be no mutual coupling between them either resistive or reactive, so that each axis may be represented independently by a separate network.

The plan of attack is to replace the three-phase armature winding by an equivalent single-phase sinusoidally distributed winding in each axis, and then to calculate the self-impedance of each circuit and also its mutual impedance with every other circuit in the axis under consideration. These impedances can then be combined to form the equivalent axis network.

It is first necessary to plot the flux-density waves produced by the armature and rotor circuits. The magneto-motive force and flux-density curves appertaining to the motor that is being used as an illustration are reproduced in Fig. 4. This machine has a uniform air gap over the pole arc. The curves for the rotor circuits are all based on the same peak value of magneto-motive force, while the armature flux waves are based on a peak magneto-motive force equal to $(4/\pi)$ multiplied by the peak value of the rotor magneto-motive force, so that the stator and rotor reactances so calculated will all be on the same base. In addition, it is assumed that there is no fringing of flux at the damper-bar circuits in the pole face, and that in consequence the flux linkage with any damper circuit can be represented by a section cut from the appropriate flux curve.

The total areas of all flux waves linking with the concentrated winding, and the peak values of the fundamentals of the flux waves linking with the distributed winding, must then be obtained. This can most readily be done by means of a planimeter and some form of electronic or mechanical harmonic analyser. The results are presented in Table I, the flux linkages with the concentrated windings being expressed as average values all based on a pole pitch, while the linkages with the distributed windings are given by half the peak values of the fundamental waves multiplied by the total number of distributed turns. These figures therefore represent to some scale the self and mutual reactances of the various windings in both the direct and quadrature axes. The scale related to the stator can be established by the evaluation of the stator winding self-reactance x_{ad} due to flux crossing the air gap.

It should be noted from Table I that the mutual reactance between any two windings is the same regardless of which winding is considered as establishing the flux. This, of course, must be the case and shows that it is not strictly necessary to analyse the complete set of flux waves in order to establish the machine constants, although it does provide a useful check.

TABLE I.—*Analysis of flux waves linking with Concentrated and Distributed Windings.*

Flux due to	Linking with	Fundamental flux amplitude	Fundamental flux linkage	Total flux	Total flux linkage
Direct axis					
Field ..	Armature	12·06	7·68	—	—
Damper 1 ..	Armature	1·76	1·12	—	—
Damper 2 ..	Armature	5·16	3·28	—	—
Damper 3 ..	Armature	8·14	5·18	—	—
Damper 4 ..	Armature	10·44	6·65	—	—
Field ..	Field	—	—	141·8	7·87
Damper 1 ..	Damper 1	—	—	16·1	0·89
Damper 2 ..	Damper 2	—	—	48·3	2·68
Damper 3 ..	Damper 3	—	—	80·5	4·48
Damper 4 ..	Damper 4	—	—	112·8	6·26
Armature ..	Field	—	—	139·0	7·72
Armature ..	Damper 1	—	—	20·4	1·13
Armature ..	Damper 2	—	—	59·8	3·32
Armature ..	Damper 3	—	—	94·5	5·24
Armature ..	Damper 4	—	—	121·2	6·72
Armature ..	Armature	12·37	7·88	—	—
Quadrature axis					
Damper 1 ..	Armature	4·10	2·61	—	—
Damper 2 ..	Armature	6·74	4·29	—	—
Damper 3 ..	Armature	8·70	5·54	—	—
Damper 4 ..	Armature	9·62	6·12	—	—
Damper 1 ..	Damper 1	—	—	40·7	2·26
Damper 2 ..	Damper 2	—	—	72·8	4·05
Damper 3 ..	Damper 3	—	—	105·0	5·84
Damper 4 ..	Damper 4	—	—	137·2	7·63
Armature ..	Damper 1	—	—	47·8	2·65
Armature ..	Damper 2	—	—	77·7	4·32
Armature ..	Damper 3	—	—	100·7	5·59
Armature ..	Damper 4	—	—	110·9	6·16
Armature ..	Armature	9·06	5·78	—	—

Col. 4 = (col. 3) $\times \frac{4}{\pi} \times \frac{1}{2}$ Col. 6 = $\frac{\text{(col. 5)} \times 1}{\text{pole pitch}}$

In the above, the contributions to the self-reactances of fluxes which do not cross the air gap were neglected. It is now necessary to calculate these leakage reactances and in the case of the rotor circuits to transfer these to the stator winding base. For instance, in the case of the field winding, it is first necessary to calculate the value of that flux which, linking with all the turns of the field winding per pole, would produce the same leakage reactance per pole as does the actual leakage flux. In order to arrive at the total field winding self-reactance it is then only necessary to increase the field self-reactance due to flux crossing the air gap by the ratio of this equivalent leakage flux to the flux crossing the air gap. An exactly similar calculation can be carried out for the remaining rotor circuits and for any slip for which the motor performance is required.

A cross-section of a damper bar is reproduced in Fig. 5, together with the variation of resistance and reactance of the bar with frequency. All rotor resistances when referred to the stator must, of course, be divided by the appropriate slip.

Table II gives values of impedances in the two axis circuits for selected values of speed.

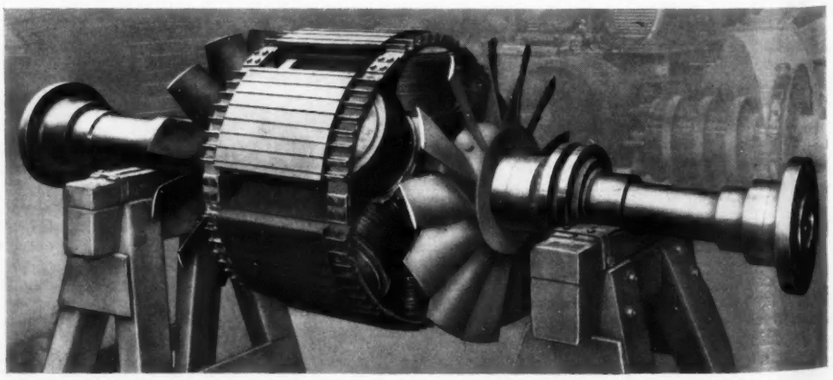


Fig. 6 Rotor of 1,600 b.h.p., 3·3 kV, 1,000 r.p.m. Metropolitan-Vickers synchronous motor to which the design calculations in this article refer.

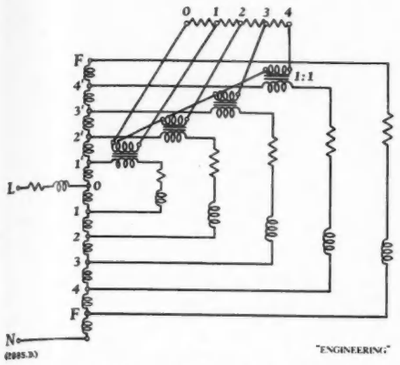


Fig. 7 Direct axis equivalent circuit.

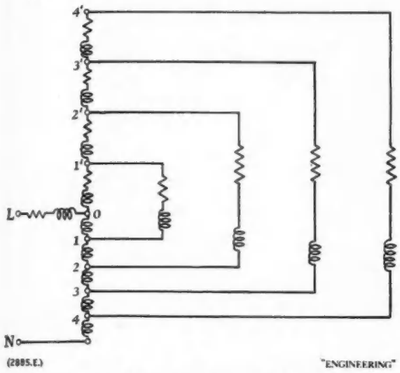


Fig. 8 Quadrature axis equivalent circuit.

The following examples serve to demonstrate how the mutual and differential leakage reactances of Table II are obtained from Table I. (The calculated value of χ_{ad} used in finding the scale factor is 0·68 per unit.)

Direct Axis.—$\chi_{3\,4}$ = (mutual reactance of armature with damper circuit 4 minus mutual reactance of armature with damper circuit 3) multiplied by scale factor $= j\,(6{\cdot}72 - 5{\cdot}24)\,\dfrac{0{\cdot}68}{7{\cdot}88}$

$= j\,0{\cdot}127$, and $\chi_{3}{}'_{4}{}'$ = (differential leakage reactance of damper circuit 4 with respect to armature minus differential leakage reactance of damper circuit 3 with respect to armature) multiplied by scale factor = [(self reactance minus armature mutual reactance) of damper circuit 4] minus [(self reactance minus armature mutual reactance) of damper circuit 3] multiplied by scale factor

$$= j\,\{(6{\cdot}26 - 6{\cdot}72) - (4{\cdot}48 - 5{\cdot}24)\}\,\frac{0{\cdot}68}{7{\cdot}88}$$

$= j\,0{\cdot}026.$

Quadrature Axis.—χ_{on} = (self-reactance of stator in quadrature axis due to flux crossing the air gap) multiplied by scale factor $= j\,(5{\cdot}78)\,\dfrac{0{\cdot}68}{7{\cdot}88}$

$= j\,0{\cdot}498.$

Except for the mutual reactances of the damper-bar circuits occurring in the end-rings, there is no difficulty about representing the resistances and leakage reactances of the rotor circuits in the equivalent circuits, and Figs. 6, 7 and 8 will be self-explanatory in this respect. It is, however, important to represent correctly the mutual resistances of the damper end-rings, especially in the quadrature axis where the resistances are considerably larger than in the direct axis.

In the quadrature axis circuit the end-ring resistances can be inserted in the differential leakage reactance branch, e.g., mutual resistance $_{3}{}'_{3}{}'$ is equal to equivalent resistance of end rings included in No. 3 damper-bar circuit minus the equivalent resistance of the end rings included in No. 2 damper-bar circuit.

In the direct axis circuit the above device is not applicable because of the current flowing in the field circuit, but the mutual resistances can be taken account of as indicated by a resistive subcircuit coupled into the damper circuits by 1-to-1 ratio coupling transformers. The mutual resistance effect in the direct axis, however, is frequently not large, and the end-ring resistances can be included in the separate damper circuits without much error.

TABLE II.—DIRECT AND QUADRATURE AXES IMPEDANCES (PER UNIT).

		Rotor frequency: 50 cycles		25 cycles		4 cycles		1·25 cycles	
		R	jx	R	jx	R	jx	R	jx
Direct axis									
Stator	L—0	0·006	0·133	—	—	—	—	—	—
Mutual reactance	1—0	0	0·096	—	—	—	—	—	—
Mutual reactance	2—1	0	0·187	—	—	—	—	—	—
Mutual reactance	3—2	0	0·164	—	—	—	—	—	—
Mutual reactance	4—3	0	0·127	—	—	—	—	—	—
Mutual reactance	F—4	0	0·073	—	—	—	—	—	—
χ_{ad}—mutual reactance	N—F	0	0·034	—	—	—	—	—	—
Diff. reactance	1′—0	0	−0·019	—	—	—	—	—	—
Diff. reactance	2′—1′	0	−0·032	—	—	—	—	—	—
Diff. reactance	3′—2′	0	−0·008	—	—	—	—	—	—
Diff. reactance	4′—3′	0	0·026	—	—	—	—	—	—
Diff. reactance	F—4′	0	0·068	—	—	—	—	—	—
Leak. reactance	D 1	0·154	0·385	0·167	0·458	0·440	0·519	1·332	0·529
Leak. reactance	D 2	0·154	0·385	0·167	0·458	0·440	0·519	1·332	0·529
Leak. reactance	D 3	0·154	0·385	0·167	0·458	0·440	0·519	1·332	0·529
Leak. reactance	D 4	0·154	0·385	0·167	0·458	0·440	0·519	1·332	0·529
Leak. reactance field		0·014	0·198	0·028	—	0·173	—	0·554	—
Mutual resistance	1—0	0·003	0	0·006	—	0·040	—	0·126	—
Mutual resistance	2—1	0·006	0	0·013	—	0·079	—	0·253	—
Mutual resistance	3—2	0·006	0	0·013	—	0·079	—	0·253	—
Mutual resistance	4—3	0·006	0	0·013	—	0·079	—	0·253	—
Quadrature axis									
Stator	L—0	0·006	0·133	—	—	—	—	—	—
Mutual reactance	1—0	0	0·220	—	—	—	—	—	—
Mutual reactance	2—1	0	0·146	—	—	—	—	—	—
Mutual reactance	3—2	0	0·104	—	—	—	—	—	—
Mutual reactance	4—3	0	0·056	—	—	—	—	—	—
χ_{aq}—mutual reactance	N—4	0	−0·029	—	—	—	—	—	—
Diff. reactance	1′—0′	0·013	−0·029	0·025	—	0·158	—	0·505	—
Diff. reactance	2′—1′	0·006	0·008	0·013	—	0·079	—	0·253	—
Diff. reactance	3′—2′	0·006	0·051	0·013	—	0·079	—	0·253	—
Diff. reactance	4′—3′	0·006	0·100	0·013	—	0·079	—	0·253	—
Impedance	D 1	0·154	0·385	0·167	0·458	0·440	0·519	1·332	0·529
Impedance	D 2	0·154	0·385	0·167	0·458	0·440	0·519	1·332	0·529
Impedance	D 3	0·154	0·385	0·167	0·458	0·440	0·519	1·332	0·529
Impedance	D 4	0·154	0·385	0·167	0·458	0·440	0·519	1·332	0·529

Where no figures are given, the impedances remain as for standstill.

SOLUTION OF EQUIVALENT CIRCUITS

The solution of the equivalent axis circuits by calculation is a lengthy and tedious process, and as a consequence it is difficult to obtain consistently accurate results by this means. The circuits are, however, entirely suitable for solution by a network analyser.

The values of $Z_{ad}(p)$ and $Z_{aq}(p)$ obtained for each value of slip can then be substituted in equation (4) to give the forward and backward rotating components of current, which in turn can then be used to obtain the torque according to equation (5). Alternatively, all the latter steps may be saved by expressing equations (4) in the form of equivalent circuits on the analyser, where Z_d and Z_q are the terminal impedances of the axes equivalent circuits. The values of torque may then be read off directly by means of power measurements as shown in Fig. 9.

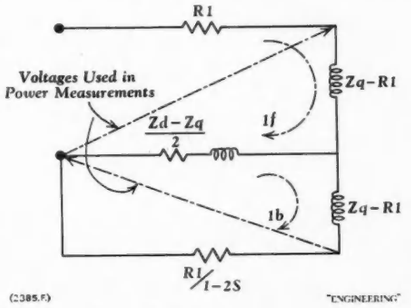


Fig. 9 Equivalent torque circuit.

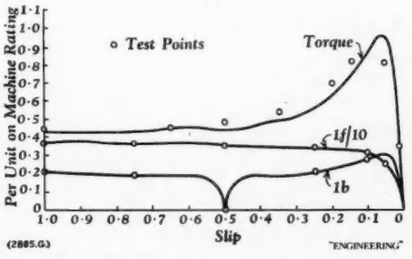


Fig. 10 Comparison of measured and calculated torques and currents.

Turning to the form of analyser best suited for this work, it has been found that the Blackburn or transformer analogue type has several advantages over the direct representation type. This is mainly because of the inherent purity with which it can represent reactive elements. With the direct type on the other hand, comparatively high ratios of reactance to inherent resistance are obtained, but because of the low power factor of the equivalent axes circuits this inherent resistance (which cannot always be compensated for by adjusting the set value of series resistance) does appreciably increase the power consumption, leading to incorrect values of torque. A further advantage when using the equivalent torque circuit is the ease with which negative resistance can be represented on the transformer analogue analyser.

Fig. 10 shows a comparison of calculated and test values of torque and current. The slight divergence of the torque curves as the motor approaches synchronous speed is partly due to the fact that for simplicity the damper winding was assumed to be at a constant temperature throughout the starting period. The close agreement between the test and calculated results is evidence of the accuracy of the method.

★ ★ ★

AERIAL SURVEY IN ANTARCTIC

An aerial survey of Grahamland and the adjacent islands of the Falkland Islands Dependencies, which will provide valuable information for assessing the scientific and mineral potentials of the area, will start towards the end of the year and will carry on throughout the Antarctic summer.

Arrangements have been made for Hunting Aerosurveys, Limited, to carry out the survey which will involve the production of a mosaic of air photographs of some thousands of miles of the most hazardous terrain in the world.

TRANSPARENT CHARTS FOR SOLVING ENGINEERING PROBLEMS

DIRECT RESULTS FROM CHARACTERISTIC CURVES

By B. B. Daly, B.SC., A.M.I.E.E., A.M.I.H.V.E.

*The solutions to problems involving up to five independent variables may be read directly from the system of charts and transparencies described in the following article. This method, in which a transparent "cursor" sheet is located over a base chart, depends on the condition of similarity, and is especially suitable, therefore, for problems in hydraulics or aerodynamics where a family of similar curves may represent the flow characteristics of, for example, a given range of pumps. Although the author has applied his method only to pipe-flow and fans, it seems possible that it may also be of use in the design of ships, turbines, aircraft and other equipment in which similarity considerations are valid; the reading of steam charts might also be simplified by a transparency technique. In addition, it may be of value for solving other problems in which trial and error or successive appoximation are normally involved. The article contains an analysis of the system and a worked-out application to flow in pipes. Extensive practical use of the system has been made by Woods of Colchester, Essex, of which company the author is chief engineer.**

While logarithmic plots and alignment charts are in general use to reduce the labour of engineering calculations, little attention has been paid to chart systems in which a sheet of transparent material (here called the "cursor"), printed with either scales or families of curves, or both, is moved over a base chart on which a system of co-ordinates is drawn. A chart on this principle was first developed by the writer about 1934 and published ten years later†; it was devised to assist in the selection of propeller, and later adjustable-pitch axial-flow fans made by Woods of Colchester, Limited.

The utility of this chart has been indicated, both by the number of copies in regular use and by the extensions that are still being made to bring new quantities characteristic of fan performance within its scope. In this article the construction of the fan selection chart is described, some general observations are put forward on the principles and limitations of the system, and as a second example, a new chart is described for the solution of the well known Colebrook-White pipe-friction equation.

FAN SELECTION CHART

The system employs a base chart of the type shown in Fig. 1, ruled logarithmically in terms of volume flow, Q, and fan pressure, P. In Fig. 1, three full lines, A_1, B_1, C_1, have been drawn to show the pressure-volume characteristics of three members of a series of axial-flow fans having the same diameter and speed of rotation but three different pitch-angle settings. A_2, B_2, C_2 are the pressure-volume characteristics of three other members of the series having the same pitch angles but a different diameter and a different speed.

It is easily shown that curves A_2, B_2, C_2 will be geometrically similar to curves A_1, B_1, C_1, but displaced by a distance $3 \log \frac{D_2}{D_1} + \log \frac{N_2}{N_1}$ parallel to the Q axis, and $2 \log \frac{D_2}{D_1} + 2 \log \frac{N_2}{N_1}$ parallel to the P axis (D is the fan diameter and N its rotational speed). These distances are derived from the well known equations of similarity for geometrically-similar fans:

$$\frac{Q_2}{Q_1} = \frac{D_2^3 N_2}{D_1^3 N_1}, \quad \frac{P_2}{P_1} = \frac{D_2^2 N_2^2}{D_1^2 N_1^2}.$$

If, therefore, curves A_1, B_1, C_1 are traced on to a transparent cursor as in Fig. 2(*b*), this cursor may be moved over the base chart (*a*) to represent the performance of a fan having any desired diameter and speed and belonging to the series in question.

LOCATING THE CURSOR

There are several ways of locating the cursor. In Fig. 2, two lines drawn on the cursor intersecting perpendicularly at O are held parallel to the Q and P axes on the base chart, while the point O is located over the line D corresponding to the diameter required and against the appropriate point on the logarithmic scale of N, marked on the diameter line. This is convenient when the fan series is made in a limited number of fixed diameters. Alternatively, a complete field of D and N co-ordinates may be drawn over the base chart as in Fig. 3(*a*), conveniently distinguished by colouring from the co-ordinates of Q and P.

The system so far described solves the problem: given the diameter D, speed N, and pitch angle, find the value of P, given Q, or of Q, given P. It is interesting to note that if the cursor be rotated through 180 deg. as in Fig. 3(*b*), it may be used to solve the inverse problem: given the volume flow Q and pressure P, find the diameter, speed and pitch angle. For this purpose, the point O on the inverted cursor is placed over the required values of P and Q on the base chart, when the curves A, B, C for the respective pitch angles will lie over the possible values of D and N on the base chart.

A third method of locating the cursor, which does not lend itself to the inversion just described but reduces the number of lines on the base chart, is shown in Fig. 4. Here the cursor is placed so that the point defining the given speed on the scale N lies over the point defining the given diameter on scale D. The horizontal line drawn on the cursor, being held parallel to the Q axis on the base chart, serves to define the orientation of the cursor.

ADDITIONAL VARIABLES

The same base chart may be used for differing designs of fan by drawing a new cursor for each series. The cursor may be drawn to record fan static or fan total pressure as desired. Efficiency may be indicated very conveniently in the adjustable pitch case by the usual "contour lines" of constant efficiency drawn on the cursor.

Similarly, constant sound-level contours may be drawn on the cursor and treated as an additive correction to a basic sound level for the particular size and speed at which the cursor is set, the basic level being determined by the intersection of a decibel scale on the cursor with a line on the base chart. A system of sound-level corrections drawn for use in the inverse cursor position of Fig. 3(*b*) is particularly useful because it permits the immediate identification of the quietest of the fan selections available for a particular duty.

Fan power may be treated in a similar manner to sound level; alternatively, intersecting scales on cursor and base chart after the manner of Fig. 4 will permit the direct determination of (for motor selection) maximum fan power, given diameter, speed and pitch angle, or (for duty power) power absorbed, given pressure, volume and efficiency. Motor torque-speed curves may be related to fan power-loading curves to

* *Editor's note*

† *G.E.C. Journal*, vol. 13, No. 1, 1944.

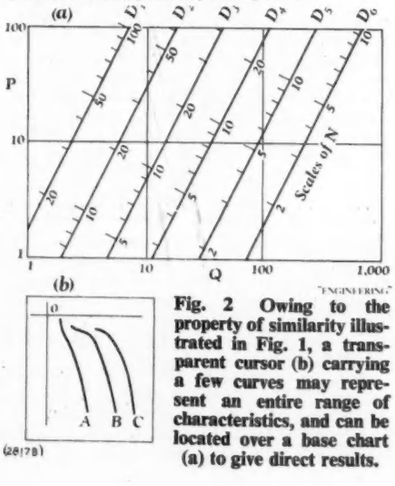


Fig. 2 Owing to the property of similarity illustrated in Fig. 1, a transparent cursor (b) carrying a few curves may represent an entire range of characteristics, and can be located over a base chart (a) to give direct results.

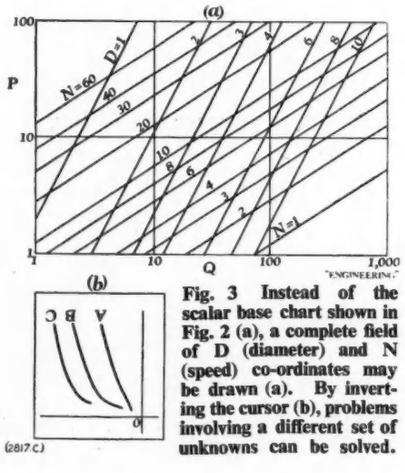


Fig. 3 Instead of the scalar base chart shown in Fig. 2 (a), a complete field of D (diameter) and N (speed) co-ordinates may be drawn (a). By inverting the cursor (b), problems involving a different set of unknowns can be solved.

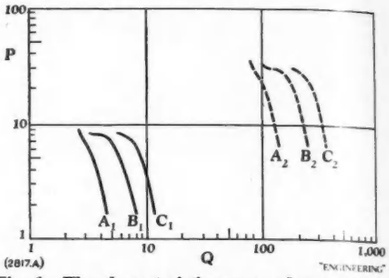


Fig. 1 The characteristic curves of pressure and volume for fans in a given series are geometrically similar and change only in position relative to the axes when conditions (such as speed and diameter) are altered.

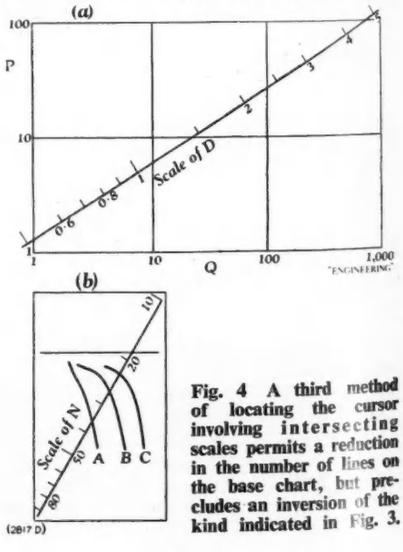


Fig. 4 A third method of locating the cursor involving intersecting scales permits a reduction in the number of lines on the base chart, but precludes an inversion of the kind indicated in Fig. 3.

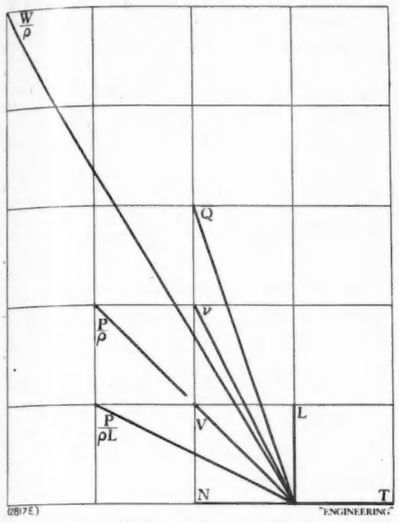


Fig. 5 Two-dimensional co-ordinate systems. In the selection of co-ordinate systems for logarithmic charts dimensional analysis can be used. The lines " L " and " T " represent the directions of constant length and time.

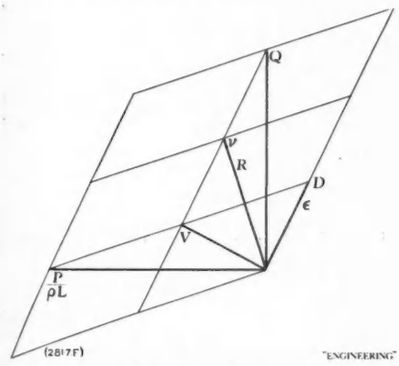


Fig. 6 Co-ordinates for pipe-friction chart. Two quantities (here Q and $P/\rho L$) are selected to form a base chart, and plotted in a rectangular system of co-ordinates obtained by skewing those of Fig. 5.

determine operating speeds. These examples by no means exhaust the possibilities of the system. In fact, a base chart of sufficiently wide range and a set of cursors will solve practically any fan performance or selection problem in a single setting without recourse to trial and error.

PRINCIPLES FOR GENERAL USE OF CURSOR SYSTEM

Since the system appears capable of extension to a wide range of engineering problems, it is of interest to examine its foundations in general terms. The essential elements appear to be:

(1) A relationship between not more than five independent variables A, B, C, D, E, which can be expressed in the following form:

$$f_1 A + f_2 C + f_3 D = \phi_E (f_4 B + f_5 C + f_6 D)$$

in which f_1, f_2, etc., are functions (usually, but not necessarily, multiples of the logarithms) of the variables A, B, C, D, while ϕ_E is that member of a series of functions distinguished by the value of the parameter E. ϕ_E need not be expressible in simple mathematical terms.

(2) A base chart with a co-ordinate system on which a point determines the values of the variables A, B.

(3) A transparent cursor lying on the base chart on which is traced a family of curves (differentiated by the parameter E) relating A to B for any fixed values of the variables C and D.

(4) Reference lines, scales or co-ordinate systems on the base chart or the cursor, or both, which enable the cursor to be moved to a position determined by the values of the variables C and D. During its motion, any straight line on the cursor should remain parallel to a corresponding straight line on the base chart.

Thus, in the example already described of a system of similar axial-flow fans having diameter, D, rotational speed, N, and pitch angle, θ, the pressure, P is related to the volume flow, Q, by the formula:

$$\frac{P}{D^2 N^2} = \phi_\theta \left(\frac{Q}{D^3 N}\right).$$

which is reducible to the form of clause 1 above thus:

$$\log P - 2 \log D - 2 \log N = \phi_\theta'(\log Q - 3 \log D - \log N).$$

UP TO FIVE INDEPENDENT VARIABLES

Other dependent variables (such as the mean air velocity, fan efficiency, or power absorbed, in the above example) can be plotted in addition to or instead of the variables mentioned, but it would appear that the total number of independent variables cannot exceed five without the use of additional cursors, or of successive movements of the first cursor after the manner of the successive movements of the slide of a slide rule.

DIMENSIONAL ANALYSIS

An ordered approach to the selection of co-ordinate systems for a logarithmic type of chart can be made through dimensional analysis. Thus, in Fig. 5, the lines marked L and T have been taken to represent the directions of constant length and constant time, respectively, on a generalised form of base chart. Then lines of constant velocity (having dimensions LT^{-1}) will follow the direction V in the figure, lines of constant volume flow ($L^3 T^{-1}$) the direction, Q, and lines of constant rotational speed (T^{-1}) the direction, N.

This is a kinematic form of diagram and cannot directly include terms involving mass. However, for problems in incompressible-fluid flow, it is possible to draw the diagram either for unit density or for the density, ρ, of the fluid most commonly employed with the particular chart, such as air at standard temperature and pressure in the above example. Terms involving mass are then divided by this density to produce a kinematic equivalent; thus pressure, P, having the dimensions $ML^{-1}T^{-2}$, is replaced by $\frac{P}{\rho}$ with dimensions $L^2 T^{-2}$ on the kinematic diagram, and lines of constant pressure take the direction shown for $\frac{P}{\rho}$ on Fig. 5. The directions given for pressure gradient, $\frac{P}{\rho L}$, and power, $\frac{W}{\rho}$, are readily entered on the diagram, while if viscosity is a factor in the problem the kinematic form, ν, having dimensions $L^2 T^{-1}$, will be employed.

The vectors in Fig. 5 thus give the directions taken by lines of constant quantity in a generalised logarithmic co-ordinate system. To complete the co-ordinate system, series of ordinates may be drawn parallel to each of the vectors in Fig. 5, the perpendicular spacing between pairs of ordinates being directly proportional to the logarithms of their values, and inversely proportional to the length of the corresponding vector in Fig. 5; the direction for increasing value is to the right looking outwards from the centre. In using this generalised form, two quantities will be selected to form the base chart, and will usually be plotted in a rectangular system of co-ordinates. This is accomplished by skewing the co-ordinates of Fig. 5 to form a system such as Fig. 6, drawn for the pipe-friction chart, in which Q and $\frac{P}{\rho L}$ are the selected quantities.

PIPE-FRICTION CHART

The pipe-friction problem provides a particularly interesting example of the application of the system. As is well known, the work of Prandtl, von Karman, Nikuradse and others has been reduced by Colebrook and White* to the following form, in which f is the friction factor $\left(\text{pressure drop} = f \tfrac{1}{2} \rho V^2 \frac{L}{D}\right)$, R is the Reynolds number $\left(R = \frac{V D}{\nu}\right)$, and ϵ is the effective roughness of the walls of a straight pipe of diameter D and length L, carrying a fluid of density ρ, and kinematic viscosity, ν, at a velocity, V.

$$\frac{1}{\sqrt{f}} = -2 \log_{10}\left[\frac{\epsilon}{3{\cdot}7\,D} + \frac{2{\cdot}51}{R\sqrt{f}}\right].$$

This formula is particularly inconvenient to solve for the friction factor, f, and while charts such as that due to Moody† simplify its application, they usually require a considerable amount of calculation before and after use.

In order to produce a chart of the type now under discussion, the Colebrook-White equation is rearranged as follows, separating D and V:

$$\log \frac{3{\cdot}7\,D}{\epsilon} - \frac{1}{2\sqrt{f}} = \log\left[1 + \frac{9{\cdot}29\,\nu}{\epsilon V \sqrt{f}}\right].$$

This can be written:

$$\log 3{\cdot}7\,D - \log \epsilon - \frac{1}{2\sqrt{f}} = \log [1 + \text{antilog}(\log 9{\cdot}29\,\nu - \log \epsilon - \log V - \tfrac{1}{2} \log f)].$$

showing that log D is related to log V for any constant values of ϵ, ν and f by a single curve of the form

$$\log D = \log [1 + \text{antilog}(-\log V)]$$

which will be simply displaced over a base chart of log D and log V by changes in ϵ, ν or f.

It seems best to select the surface roughness, ϵ, and the kinematic viscosity of the fluid, ν, as the two variables which fix the position of the cursor, since both these quantities will probably be constant in any group of calculations. The base chart will then carry the co-ordinate system for D and V while the cursor will carry a series of similar curves with successive fixed values of the friction factor, f, as parameter.

PRESSURE GRADIENT AND FRICTION FACTOR

With the cursor set for given values of ϵ and ν, any point on the chart now records corresponding values of D, V and f. If the fluid is taken to be of unit density, the dynamic pressure can be calculated from V and the pressure drop per unit length of pipe (the pressure gradient) obtained by multiplying by $\frac{f}{D}$. If the base chart is drawn so that lines of constant pressure gradient are horizontal, the pressure gradient (at unit density) can be obtained by following the direction of a family of guide lines drawn on the cursor from the point (V, D, f) to a scale of pressure gradient located on the base chart.

For the horizontal axis of the base chart, Q is preferable to V, since it is the more likely of the two to be the design requirement. After scales have been selected, the base chart and cursor can now be constructed. Lines of constant Reynolds Number lie on the cursor and are parallel to the directions of constant kinematic viscosity, and of constant product, V D. The friction factors and correction lines in the viscous region can therefore be plotted on the cursor, since in this region the friction factor depends solely on Reynolds Number.

The completed chart and cursor are shown in Figs. 7 and 8. The scales have been chosen to cover the entire range of diameter, velocity, surface roughness and kinematic viscosity (except for very viscous fluids) likely to be met in practical problems in any field of fluid flow. Although, if the chart is drawn to foolscap size, these scales are inevitably cramped, it is never-

* Colebrook, C. F., " Turbulent Flow in Pipes with Particular Reference to the Transition Region between the Smooth- and Rough-Pipe Laws." *Jl. Inst. C.E.* vol. 11, page 133, 1939.

† Moody, L. F., " Friction Factors for Pipe Flow." *Trans. A.S.M.E.*, vol. 66, page 671, 1944.

theless possible to read values of friction factor with all the accuracy justified by existing experimental data in the region of turbulent rough-pipe flow. Although the scale of pressure gradient on the chart can only be read to a very limited accuracy, values of pressure drop can in practice be calculated to any justifiable standard of precision from the friction factor and the dynamic pressure.

ELIMINATION OF TRIAL AND ERROR

The provision of a scale of pressure gradient does permit a logical approach to pipe design not available with other calculating systems. In this approach the kinematic viscosity ν, of the fluid to be pumped, and the surface roughness, ϵ, of the material to be used for the pipe, are supposed to be known; these fix the location of the cursor. It is next supposed that the quantity of fluid to be moved Q is specified, as is the pressure available and the length over which the fluid is to be transported. The last two factors, divided by the fluid density, give the pressure gradient, H, in the terms of the chart. It is therefore possible to enter the chart at the required values of Q and H, and to arrive directly at the pipe diameter, D, that is required to meet the available pressure gradient.

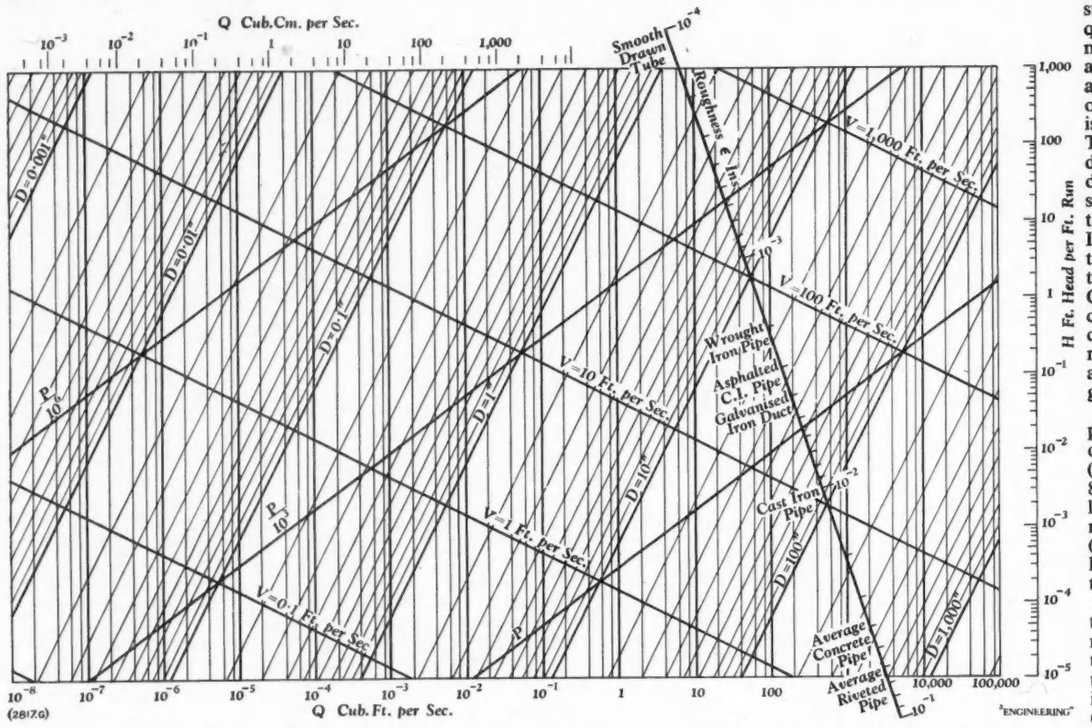


Fig. 7 Base chart for fluid flow through straight pipes of circular cross-section. It is used with the cursor in Fig. 8.

In working from the Colebrook-White formula on the other hand, or any of the published charts based on it, it is necessary to know the diameter, D, before the factors $\frac{D}{\epsilon}$ and R can be evaluated. The design process must therefore be one of trial with successive values of D until a value is found which gives an acceptable pressure gradient.

If the use of the cursor of Fig. 8 establishes that the flow is in the viscous region below the critical Reynolds Number, the Hagen-Poiseuille formula:

$$Q = \frac{\pi D^4}{128 \mu} \frac{P}{L}$$

becomes applicable.

In this formula neither the fluid density, ρ, nor the surface roughness, ϵ, appear, since neither has any influence on the pressure. The absolute viscosity, μ, replaces the

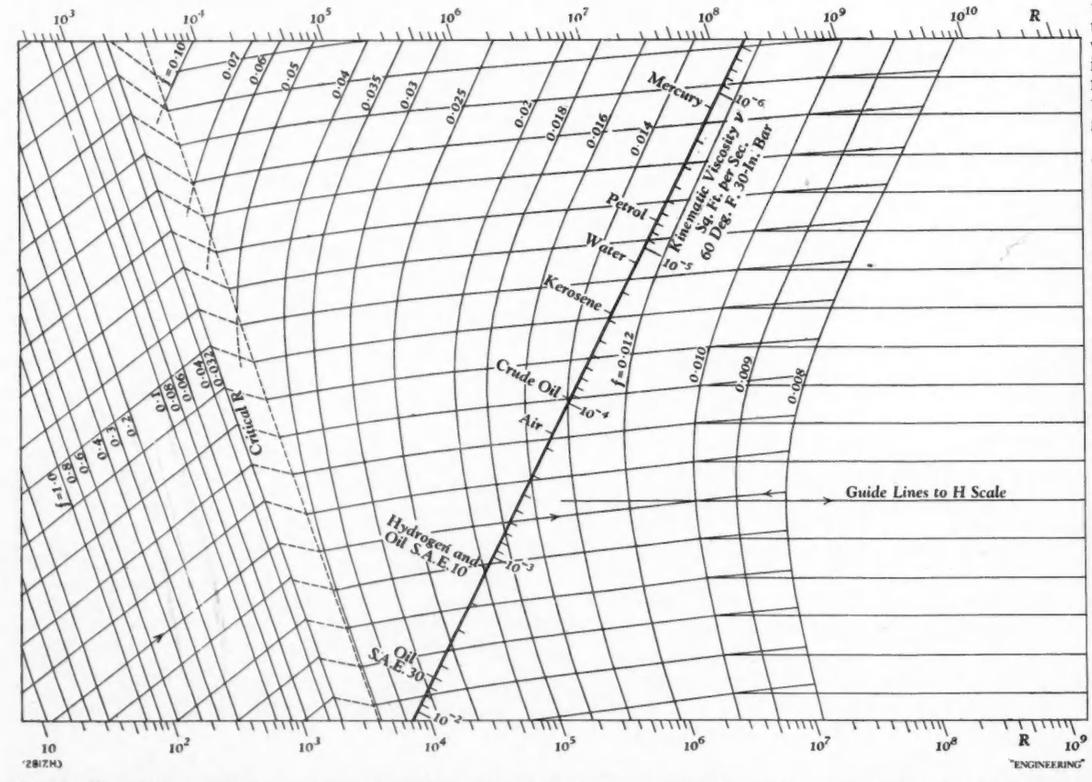


Fig. 8 For solving problems concerning pipe friction a transparent cursor marked out in the manner shown can be located on the base chart illustrated in Fig. 7. It is likely that systems employing transparent cursors may be used to simplify similar calculations in other fields.

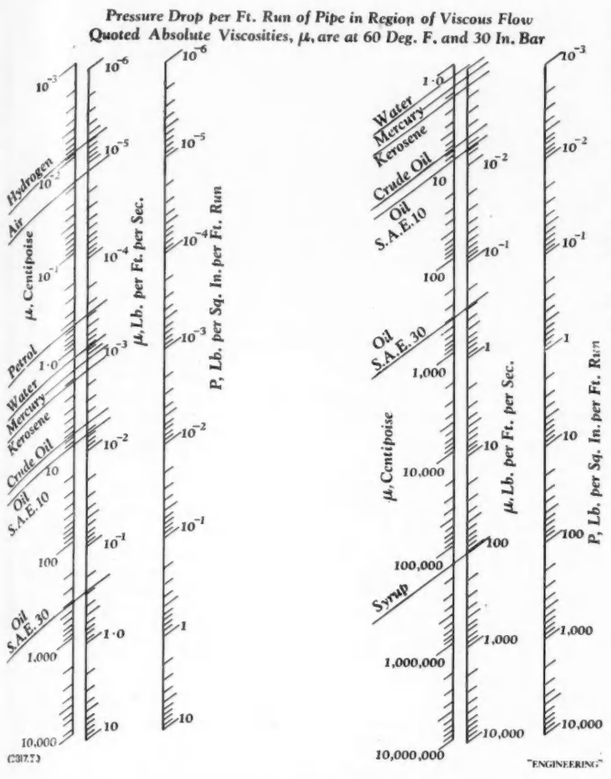


Fig. 9 An alternative form of transparent cursor, employing scales only, which may be located over the base chart of Fig. 7 when flow is in the viscous region. It is used to determine the pressure gradient when fluid viscosity (μ), flow (Q) and pipe diameter (D) are known; while Fig. 8 applies to both turbulent and viscous flow, bringing in the pipe roughness (ϵ) and kinematic viscosity (ν).

kinematic viscosity, ν. A second cursor (Fig. 9) can now be drawn to determine the pressure gradient, when the fluid viscosity, μ, the rate of flow, Q, and the diameter, D, are known. Since the Hagen-Poiseuille formula has only four variables, simple scales on the cursor provide the solution, without the necessity for a family of curves (such as those of the friction factor, f, in Fig. 8 representing the fifth variable in the Colebrook-White formula.)

The viscous-flow cursor consists of a transparent sheet marked out as indicated in Fig. 9 and may be used to determine the pressure gradient in any particular case in the following manner: the scales of absolute viscosity (μ) are held parallel to the lines of constant flow (Q) on the base chart (Fig. 7); the value on the μ scale representing the viscosity of the given fluid is placed over the appropriate values of D (pipe diameter) and Q; the pressure gradient is read on the cursor scale at its intersection with the reference line (P) on the base chart; finally it is necessary to multiply the result by the appropriate factor on the reference line.

SCOPE OF SYSTEM AND ITS PRACTICAL APPLICATION

The new charts do not lend themselves to adequate illustration in an article of this kind, but some insight into their use can be gained if the cursor in Fig. 8 is traced on to cloth, or drawn on "Kodatrace," and moved over Fig. 7. Readability is greatly improved if the chart is drawn to a larger scale, preferably with the co-ordinate systems distinguished by different colours, and if the cursor is reproduced photographically on sensitised transparent plastic material, or by printing. For permanent use in a design office, the cursor can be attached to a drafting machine to ensure parallel motion, and a movable scale of pressure gradient can be located against a scale of density on the base chart to give pressure drops directly for fluids of any density.

It is hoped that these two examples dealing with fan selection and pipe friction will sufficiently illustrate the possibilities of the system. It would seem particularly adapted to fluid-flow problems where arbitrary relations between velocity, size, pressure, drag, sound level, heat transfer and other variables are expressed with dimensionless factors involving products and powers of the variables. Experience has shown that the initial trouble of producing a chart and a few cursors is well repaid by the facility with which a wide field of size, speed, etc., can be explored.

* * *

CHECKING MACHINE USAGE

Operating Time Recorded

For many purposes it is desirable to know exactly how many hours a particular machine has actually run, and for this task a device known as a "Horameter" has been introduced to this country by Target Services, 6–11 Dorset-close, Gloucester-place, London, N.W.1. Fundamentally, the device is an electric clock which is switched on and off with the machine. It is shown in the illustration below, together with its fixing bracket.

The device is driven by clockwork which has an automatic electro-magnetic mechanism for winding the spring. This mechanism can be energised by either direct or alternating current as desired, enabling the Horameter to be used on all machines whether they are electrically driven or not. In the latter case, the supply can be taken from a 6-volt dry battery through a switch which is closed when the machine is started. Models are made for direct-current supplies of 6, 12, 24 or 110 volts, and for alternating currents at 110 or 230 volts. The device will register up to 10,000 hours and shows tenths of hours in red. The weight is 19 oz. and the size $2\frac{3}{8}$ in. diameter and $3\frac{1}{4}$ in. deep. For flush mounting in a panel it is held by a U-piece of the type shown in the illustration.

Shown here with standard fixing bracket, the Horameter is a recording clock for machine usage with an electrically-wound movement.

* * *

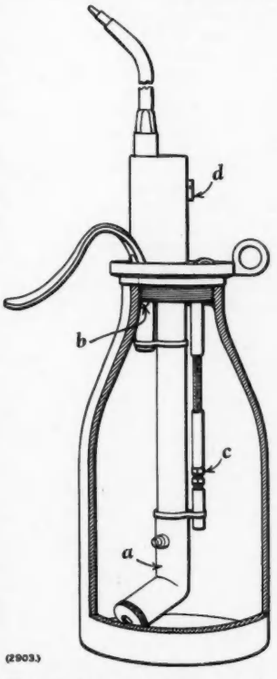
CONTROLLED LUBRICATION

Pressure Oil Gun with Calibrated Delivery

Now available in this country through the agency of Sir Thomas Edelston and Partners, Limited, 28/30 Sussex-place, London, W.2, is the Reilang twin-pump oil gun, which is made by H. Chappuis and Company, of Zurich. A part section of the gun is shown below.

The gun is operated by squeezing the handle which draws up the inner tube, forcing the oil contained in the latter through the nozzle. In order to use the full volume of the container, the suction valve is at the end of an L-shaped extension *a*, which is free to swivel. Its own weight therefore ensures that the valve will always point towards the lowest part of the container when the nozzle is uppermost. In order to be able to use the gun when the container is uppermost, a second intake is located at *b*, which operates when the oil is around it. To control the amount delivered at each stroke, the length of the stroke can be preset by adjusting the nuts *c* on the operating rod. The oil can be metered quite accurately in this way. Delivery is through two non-return ball valves which can be reached for cleaning through the screw *d*.

The container is an aluminium casting which will withstand much hard treatment, including being dropped on concrete floors, without sustaining any damage. The mechanism screws into the container, giving a wide mouth for filling and being sealed with a rubber ring. It is claimed that there is no leakage from the nozzle in any position of the can, so that it is always clean to handle. For this reason, as well as for the metered delivery, the gun has proved popular in food and textile works and other places where cleanliness is required. Three sizes are available with capacities ranging from about $\frac{1}{2}$ pint to just over 1 pint; different lengths of nozzle can also be fitted.



The Reilang oil gun can be operated in any position. It has an adjustable stroke to meter the delivery and is claimed to be leak-proof.

Fig. 1 The design of the new Franco-Crosti locomotives is as far as possible similar to that of the British Railways standard 2-10-0 heavy freight engines. Ten locomotives are now being built at Crewe Works.

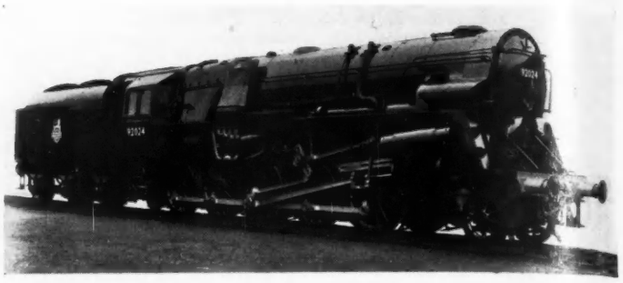


Fig. 2 The normal chimney is blanked off, except when lighting up, and the firebox gases, after passing through a feed-water preheater, are exhausted through a "final" smokebox on the right-hand side of the boiler.

PREHEATERS FOR INCREASED EFFICIENCY OF STEAM LOCOMOTIVES

BRITISH RAILWAYS APPLY THE FRANCO-CROSTI SYSTEM

Ten heavy freight locomotives which British Railways are building at Crewe are expected to show increased efficiency as a result of the feed-water preheating system with which they are fitted. In the orthodox steam locomotive the firebox gases, after leaving the boiler tubes, waste a substantial amount of heat as they are ejected to the atmosphere through the chimney. With the Franco-Crosti system, however, the gases, after leaving the boiler tubes, are passed through tubes in a secondary drum, or drums, where they impart some of their remaining heat to the feed-water. The water is fed to the preheater by an injector or pump, and is under practically the same pressure as the main boiler. It is delivered thence to the boiler through clack valves. The preheater tubes provide 1,021 sq. ft. of heating surface, compared with 1,274 sq. ft. for the boiler tubes.

The standard heavy freight locomotive of the British Railways' range is the Class 9 2-10-0, which is a two-cylinder locomotive of orthodox design having a normal wide-firebox boiler. The type was described in ENGINEERING, vol. 177, page 158 (1954).

Shortly after the design of this locomotive was commenced, consideration was given to the possibility of obtaining experience with the Franco-Crosti boiler, an Italian invention which has been experimented with in Italy and Germany. It was, therefore, decided to build ten of the standard Class 9 locomotives with this type of boiler in conjunction with the Societa Per Azioni Locomotive a Vapore Franco-Crosti, of Milan. The design work was carried out at Brighton, initially under the direction of Mr. R. A. Riddles, C.B.E., Railway Executive Member for Mechanical and Electrical Engineering, and subsequently under the direction of Mr. R. C. Bond, Chief Mechanical Engineer of the British Transport Commission. Close consultation was maintained throughout with Dott. Ing. Piero Crosti of Milan, the inventor of the system. The general layout was made with as few modifications as possible from the orthodox Class 9, some parts of which, in accordance with the practice followed on the British Railways standard locomotives, were designed at Derby, Doncaster and Swindon, The aim was to render possible conversion either way in the light of experience. The ten locomotives, Nos. 92020-92029, are being built at Crewe and several have now been completed. One is illustrated in Figs. 1 and 2.

HEAT FROM EXHAUST STEAM

In the Franco-Crosti system the water enters the boiler proper at a temperature only slightly less than that of the water already in the boiler. In this way a large amount of heat is utilised which would otherwise be wasted. Some heat is also extracted from the exhaust steam by (1) a jacket encircling part of the preheater drum or drums, this being fed with exhaust steam, which imparts some of its heat to the relatively cold water fed by the feed pump or injector; or (2) by using an exhaust-steam injector.

The water circuit is as follows (see Fig. 4). The cold feed from the tender is forced through a clack valve on the firebox end of the preheater, either directly by means of a feed pump, or else after mixing with steam in an injector. The water in the preheater, which is at approximately boiler pressure, is displaced by fresh feed entering and moves up towards the hot end, whence it passes by way of pipes to the main boiler clack valves. The main boiler is of the normal type having no special features, except that for a given power it can generally be made a good deal smaller than the boiler of the corresponding orthodox locomotive.

The principle of the preheater is "contra-flow," i.e., the hot gases and cold water flow in opposite directions. This enables the maximum amount of heat to be extracted from the gases as the temperature gradient between gases and water is more or less uniform at all stages, the coldest water being heated by the coldest gases at the remote end of the preheater and likewise the hottest water, in the vicinity of the firebox, being heated by the hottest gases.

The expected economies arise not only from the heat extracted from the gases and the exhaust steam, which would otherwise escape from the chimney, but also from the incidental increase in combustion efficiency which should result from the less quantity of coal burned. However, the gases require more energy to pull them through both banks of tubes, tending to necessitate a higher blast-pipe pressure which causes a slight loss of cylinder efficiency.

The attractive feature of the Franco-Crosti system is its simplicity, all the advantages of feed-water heating being obtained without the use of any additional moving part on the locomotive.

There are various ways in which the preheater drum, or drums, can be accommodated on the locomotive frame. In some Continental arrangements two drums are placed one on each side of the boiler, with the final chimneys emerging on either side of the barrel just in front of the firebox. The direction of the gases is thus reversed at the front smokebox and thereafter they travel rearwards. The British loading gauge is very restrictive, and with a locomotive of the size of the Class 9 2-10-0 it was physically impossible to dispose the drums in this manner. Instead, one drum only is provided, placed between the frames underneath the main boiler barrel, the centreline of the drum sloping downwards to the rear (Figs. 4 and 5). The drum has a final smokebox, located just in front of the throatplate of the main boiler, and the blast chamber and final chimney are placed on the right-hand side of the barrel, just ahead of the firebox.

BOILER MODIFICATIONS

The backplate of the boiler proper and the disposition of the controls are identical with those of the standard locomotives. The ashpan and grate are also the same; the former is of the self-emptying type and the latter has twelve rocking sections, each fitted with twelve grid-type firebars. Elsewhere the boiler is different, being smaller in diameter, but otherwise similar in principle, with a Belpaire firebox, a combustion chamber, regulator in the dome, superheater, etc.

The outside diameter of the boiler barrel is 4 ft. 11⅛ in., increasing to 5 ft. 7½ in. at the firebox end, compared with 5 ft. 9 in. and 6 ft. 1 in., respectively, for the standard engine. The length between tubeplates is greater (16 ft. 5 in. instead of 15 ft. 3 in.). There are fewer large flue tubes (28 5½-in. tubes compared with 35 5¼-in. tubes), and very much fewer small tubes (60 2⅜-in. tubes compared with 138 2-in. tubes).

The front smokebox is a welded vessel rigidly attached to the front of the main boiler barrel; the latter rests on main supports under the front barrel ring and is there rigidly attached to the frame. Expansion of the front smokebox is permitted forwards, and expansion brackets carry the weight on to the front ends of the frame plates. The gases entering the front smokebox from the boiler tubes pass to the front and over a vertical deflector plate which is provided to trap the smokebox char. They then pass downwards into a pocket which forms the entrance to the preheater tubes, fitted with the lower deflector which is curved to lead the gases into the preheater tubes.

Two smokebox doors are fitted; the upper one, being the larger, provides general access to the

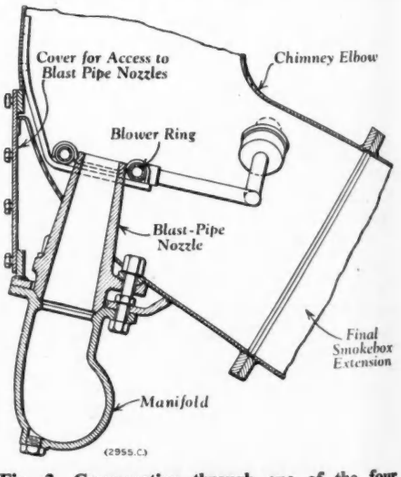


Fig. 3 Cross-section through one of the four blast-pipe nozzles, which are arranged longitudinally on a common manifold and discharge into the "final" smokebox on the side of the boiler.

front tubeplate of the main boiler. When it is open the centre portion of the vertical deflector plate, which is hinged, can be lowered to form a platform over which any accumulation of char can be swept out. The lower door is for access to the front tubeplate of the preheater, but before this can be reached it is necessary to remove the curved deflector plate.

The chimney on the front smokebox is only required for lighting-up and is therefore fitted with a door which is closed for normal running and secured by means of a central dart.

The superheater header, of orthodox design, is accommodated in the front smokebox and there are 28 elements of the bifurcated type, 1¼-in. outside diameter and 9 s.w.g. thick, with the Superheater Company's ball end. The main steam pipes to the cylinders pass forwards to the front of the box and then downwards, passing out horizontally from the "ears" of the box through glands which allow free expansion of the box forwards in relation to the steam pipes.

PREHEATER

The preheater is a welded drum 2 ft. 7⅞ in. diameter inside, containing 90 steel tubes of 2¼-in. outside diameter, 19 ft. 3 in. between tubeplates. It is riveted by means of a circular flange to the front smokebox and is carried also by diaphragm plates suspended from the main boiler barrel. It is illustrated in Fig. 5 and was supplied by Babcock and Wilcox, Limited.

Elbows are welded to the top of the barrel at the front, to which are connected the feed pipes to the main boiler. Clack valves are placed on the rear end of the preheater barrel and are fed by the injectors. A large manhole is provided for access to the preheater for inspection of the inner surfaces when the tubes are removed, and the cover is fitted with a safety valve set to 275 lb. per square inch, to prevent the possibility of excessive pressure.

The rear portion of the preheater is enveloped in a jacket into which is passed a small quantity of exhaust steam drawn from the left-hand cylinder exhaust pipe. This enters at the top of the front of the jacket and is intended to impart its heat to the feed-water in the preheater and mainly be condensed. To take away any air which accumulates from the steam, outlets are provided towards the bottom of the jacket, at the rear end, and these pass to the final smokebox, where the draught should be sufficient to suck out the air and promote a small circulation of the steam through the jacket. A sump at the bottom of the jacket is fitted with a "Spirax" steam trap to take away the condensate.

The boiler is fed by two injectors mounted exactly as in the case of the standard locomotives. The exhaust injector is a Davies and Metcalfe type K with 11-mm. cones. The live-steam injector is a British Railways standard pattern with 10-mm. cones. Both are mounted on the right side and normally deliver water direct to the preheater, but in an emergency water can be fed directly to the boiler by unsealing and turning a two-way valve fitted in the live-steam injector delivery pipe-line. This directs the feed into a pipe running up to a separate clack valve on the front barrel ring.

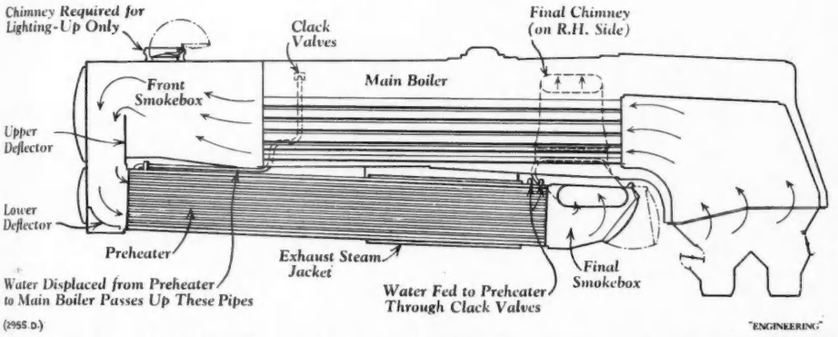


Fig. 4 The Franco-Crosti boiler as adopted by British Railways. Arrows show the path of the hot gases: from the firebox, through the boiler tubes, into the front smokebox, down to the preheater, through its tubes, up into the final smokebox where four blast-pipes create the draught.

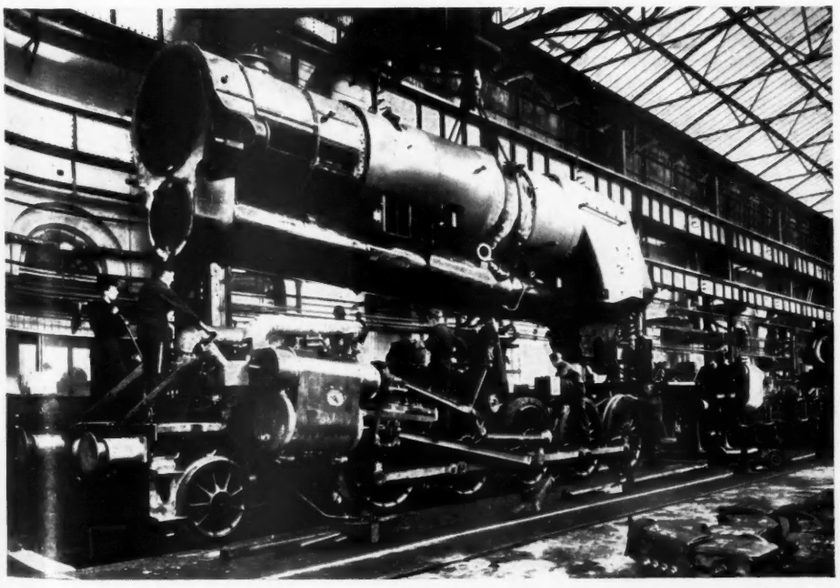


Fig. 5 The boiler with the preheater underneath, as shown in the drawing Fig. 4.

Comparative Dimensions of Standard and Franco-Crosti Locomotives

—	Standard	Franco-Crosti.
Cylinders (2), dia. and stroke	20 in. by 28 in.	
Wheels, coupled, dia.	5 ft.	
Wheelbase, coupled	21 ft. 8 in.	
Heating surfaces:		
Main boiler: tubes	1,836 sq. ft.	1,274 sq. ft.
firebox	179 ,,	158 ,,
Total evaporative	2,015 ,,	1,432 ,,
Superheater	535 ,,	411 ,,
Preheater: tubes	—	1,021 ,,
exhaust-steam jacket	—	57 ,,
Free flue area (boiler)	5·49 ,,	4·59 ,,
,, ,, (preheater)	—	2·0 ,,
Grate area	40·2 sq. ft.	
Boiler pressure	250 lb. per sq. in.	
Tractive effort	39,667 lb.	
Weight of engine in working	86 tons 14 cwt.	90 tons 4 cwt.

FINAL SMOKEBOX

The final smokebox is rigidly attached to the rear end of the preheater drum and is of welded construction. It has a door at its rear end hinged from the top.

The final smokebox has a tubular extension to the right side of the locomotive leading to the blast chamber, or elbow, which houses the blast-pipe nozzles, as shown in Fig. 3. The blast chamber is placed on the right of the locomotive so as not to interfere with the driver's view ahead. The fireman's view is, however, slightly more obstructed than with normal locomotives. The chimney, of "oval" shape, is attached to the top of the blast chamber and passes upwards, inclined towards the centre of the locomotive, being made as high as the loading gauge will permit and in such a way as to enable the exhaust to clear station awnings as far as possible. To reduce corrosion in the final smokebox, blast chamber and chimney, the whole of the inner surface of these details is treated by the Calorization process, consisting of a deposit of aluminium and aluminium oxide.

To carry the weight of the blast chamber a substantial bracket from the main frame is provided, the chamber resting on this through a sliding bearing to allow for expansion of the preheater. The chimney is located laterally by means of a pin-jointed stay from the boiler barrel. The base of the blast chamber surmounts an exhaust manifold which is connected at its front end to the combined exhaust-steam pipe from the cylinders. The manifold carries the four blast-pipe nozzles of 2¼-in. diameter, which are mounted in a straight line so as to exhaust into the "oval" chimney. Each nozzle has a spherical mounting so that it can be adjusted to direct its steam jet correctly into the chimney. A removable plate on the outside of the blast chamber provides access to the nozzles for removing deposits of carbon.

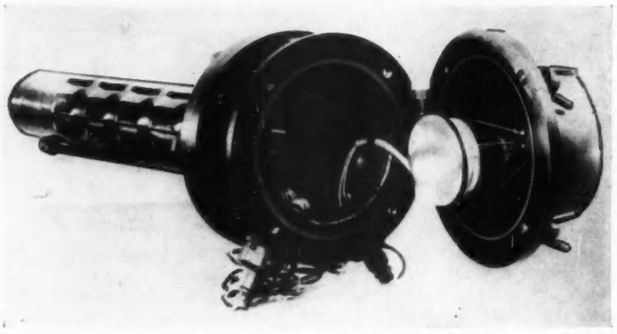
The lagging of the boiler, firebox and preheater consists of light-weight asbestos mattresses, covered by the normal steel clothing sheets. The front smokebox is provided with clothing sheets but no lagging material is interposed. The steam jacket of the preheater is dealt with similarly.

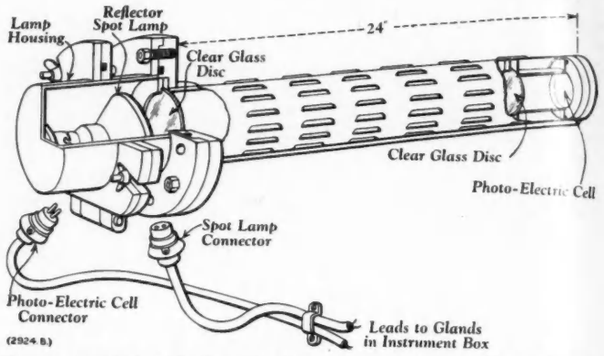
FRAMES

The frames follow as closely as possible those of the standard Class 9 2-10-0. They consist of 1¼-in. plates rigidly stayed by means of vertical and horizontal stretchers, some of which have had to be slightly modified to accommodate the preheater. As in the case of the standard engine the frame plates are located in the planes of the centre-lines of the coupled axleboxes, with the hornblocks of symmetrical horseshoe form welded in. The smokebox saddle has been eliminated and in its place there is a large stretcher shaped to fit under the preheater. The front of the main boiler is carried on a saddle rivetted to the barrel near the front tubeplate and supported on a T-shaped flange welded to the top edge of the main frame plates.

Comparative dimensions of the standard and Franco-Crosti locomotives are given in the table above. Design particulars which are common to both types are given in the previous article on the standard engine.

(*Editorial comment in Weekly Survey*)





The oil-mist detector probe unit is inserted through a hole in the engine crankcase, to which it is flange-bolted. At the remote end it encloses a photo-electric cell. The lamp housing outside the crankcase is hinged to provide for changing the lamp and testing the cell. Louvres in the probe body admit any oil mist present, which attenuates the light falling on the photo-electric cell and causes a relay to operate.

DETECTING OIL MIST IN DIESEL CRANKCASES

PREVENTING EXPLOSIONS IN SHIPS' ENGINES

This article gives a description of the Graviner-B.S.R.A. oil-mist detector for Diesel-engine crankcases, and the considerations which led to its development. The detector is now undergoing trials in five ships.

It has been observed that, on an average, every year some 10 or 12 explosions occur in ships' Diesel engines. To guard against such incidents resulting in destruction and damage to equipment and injury to personnel, it is the practice to provide venting doors in the crankcases of Diesel marine-propulsion engines, and in general the results of a crankcase explosion are not serious. Occasionally, however, they can be disastrous, as in the case of the Reina del Pacifico during her trials after refitting at Belfast in September, 1947, when an explosion occurred in which 28 people lost their lives. With a large ship's engine, moreover, the venting of a sheet of flame into the engine room can itself constitute a hazard to the men on duty, and it seems that a better approach to the problem might be to detect the onset of conditions likely to give rise to an explosion and to take steps to counteract them.

For this reason, in 1948, the British Shipbuilding Research Association placed a contract for a comprehensive investigation into the causes of crankcase explosions in Diesel engines, at the Imperial College of Science and Technology, under the direction of Dr. J. H. Burgoyne and Professor D. M. Newitt, who have recently described the results of their investigations in a lecture before the Institute of Marine Engineers, entitled "Crankcase Explosions in Marine Engines." In brief, their conclusions were that most crankcase explosions were probably due to "the formation and subsequent ignition of lubricating oil mist in contact with an overheated engine part. . . . . The observation that the optical density of an oil mist at the lower explosive limit of concentration is very high, whereas barely visible mists arise in normal engine running, suggests that a warning system based upon the interruption of a beam of light in the crankcase, should be of very practical value."

In 1954, therefore, the British Shipbuilding Research Association invited the Graviner Manufacturing Company, Limited, Gosport, Hampshire, to develop an oil-mist detector that would warn engine-room personnel when the oil-mist concentration in the crankcase approached a dangerous value. The engineer in charge could then take the necessary action to prevent an explosion occurring, either by stopping the engines for investigation or by flooding the crankcase with an inhibiting fluid, most probably carbon dioxide, since this is non-toxic in contact with hot metal and since most ships are already equipped with CO_2 installations for fire-fighting. Alternatively, the detector could be used to trigger an automatic inhibiting system, simultaneously with the operation of the alarm signal.

USE OF PHOTO-ELECTRIC CELL

The instrument developed by the Graviner company shown in the illustrations above employs a simple photo-electric cell of the barrier-layer type, which directly energises an electro-magnetic relay, without amplification. The cell is fitted at one end of a steel probe 2 ft. long, which is inserted through a hole in the engine crankcase, to which it is flange-bolted and coated, with a sealing medium to prevent oil seepage. A hinged lamp housing on the end of the probe outside the crankcase contains a 75-watt 220-volt direct-current lamp, the light from which is directed on to the photocell. Louvres in the steel probe are arranged to admit oil mist but shed any oil spray so that it cannot obscure the light beam. At each end of the probe are clear glass discs to protect the lamp and the photocell.

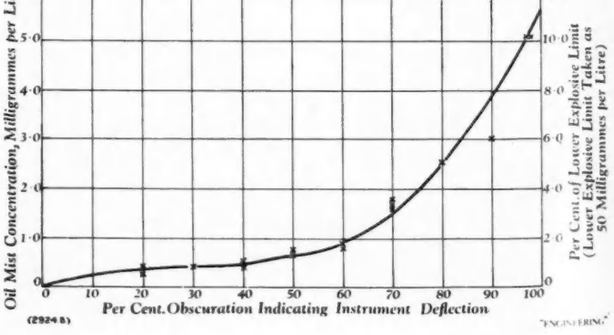
The location of the detector probe is carefully selected to detect the most likely sources of overheating such as pistons and cylinder skirts, and certain auxiliary bearings. Failure of the main bearings will generally be revealed by the melting of the white-metal linings before sufficient heat is generated to cause the formation of an oil mist in explosive concentrations. Generally speaking it is considered that one probe will be sufficient for two and possibly even for three crankcase chambers, unless the crankcase is such that the webs form oil-mist shields for the probe, in which case one probe for each chamber will be necessary.

The relay energised by the photocell is housed in a control box on which are also mounted a green light which is illuminated when the instrument is switched on; a red warning lamp; and an alarm bell. In the original experimental installation at the Graviner works, the relay operates a micro-ammeter, in addition to the warning light and an alarm bell. The micro-ammeter, graduated from 0 to 100, is calibrated so that it indicates 100 when there is no oil mist to obscure the light falling on the photocell, and 0 at total obscuration. As shown by the calibration curve below, obtained by Dr. Burgoyne's staff, in a chamber simulating an engine crankcase, an 80-per cent. obscuration corresponds to an oil-mist concentration of 2·5 mg. per litre, which is 5 per cent. of the lower limit of explosive concentration. This value has been selected for the trial installations as the critical value at which the red warning light is illuminated, the green "instrument-on" indicator light is extinguished, and the alarm bell sounds. The latter can be switched off, but the red warning light will still show until the oil-mist concentration falls below the critical value.

It should be noted that the hinged lamp housing, which provides for changing the lamp, also forms a simple means for testing the photocell, since as the lamp is swung about the hinge the light falling on the photocell is attenuated and this fact is indicated by the warning light and on the micro-ammeter, if fitted, if the cell is working properly. It is probable that when the instrument is installed in ships' engines, the micro-ammeter would not be used.

SHORE DIESEL INSTALLATIONS

In April five ships were fitted with Graviner oil-mist detectors for evaluation—m.v. Portland Auckland (Port Line), m.v. Essequito (Royal Mail Lines), m.v. Durham (New Zealand Company), m.v. Cyclops (Alfred Holt), and m.t. Neritopsis (Anglo-Saxon Petroleum Company). It is expected that if, at the end of the trial period the instruments prove to be satisfactory in service, they will be recommended for adoption by the manufacturers of marine propulsion engines. Should an automatic inhibition system be favoured, the relay can easily be adapted to operate the inhibitor release mechanism simul-



Calibration curve of oil-mist detector.

taneously with giving the alarm. Makers of land-installation types of Diesel engines, in particular those employed in gas works, as well as for ships' auxiliaries, are also showing considerable interest in the oil-mist detector; in smaller plants there is also the possibility of installing an effective explosion-suppression system operating on the principle described in the article on page 493 of our April 16, 1954, issue (vol. 177) whereby the explosion is detected and inhibited before the pressure rise has exceeded about 2 or 3 lb. per square inch.

FLUID SEAL FOR RECIPROCATING SHAFTS

COMPOUND U-RING AND HEADER

To provide a convenient and effective gland suitable for applications involving the reciprocating motion of a shaft, Hall and Hall, Limited, 88 Leadenhall-street, London, E.C.3, have developed their "Hallprene" patent fluid seal. It consists basically of a U-ring of synthetic-rubber impregnated fabric with a square base; into the U-recess is moulded synthetic rubber, which is brought forward of the lips of the seal to form a nose, and serves in effect as a header or spreader ring. The two parts are bonded together to give a neat internal unit, having the cross-section shown at (*a*) in the accompanying illustration. The seal is made of a material unaffected by such pressure media as oils, and may therefore be used for such purposes as sealing the cylinders of hydraulic rams. The makers claim that the seal minimises leakage and friction, and approximate performance figures for its operation in different circumstances are provided. Moreover, it is easy to fit, compact and economical in space, capable of accommodating misaligned and scored rams, and able to endure heavy handling without its sealing efficiency being seriously impaired.

The synthetic-rubber impregnated fabric U-piece is so moulded that the walls diverge slightly, thus giving a greater distance across the lips than across the base. This divergence is carefully designed to ensure that, while the base is clear of the ram and the bore of the stuffing box, the splay of the lips is sufficient to provide the required degree of initial interference for sealing slack oil.

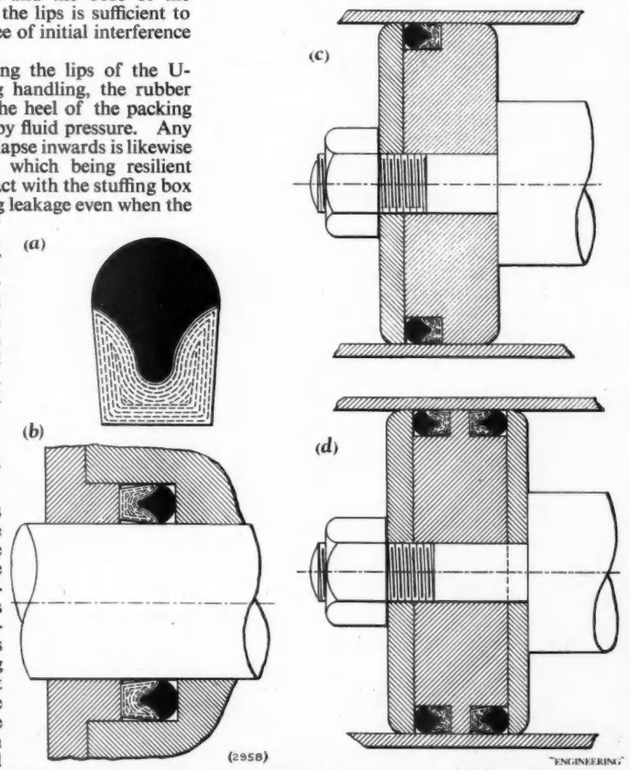
In addition to protecting the lips of the U-ring from damage during handling, the rubber filling prevents wear at the heel of the packing due to distortion caused by fluid pressure. Any tendency for the lips to collapse inwards is likewise prevented by the filling, which being resilient maintains the lips in contact with the stuffing box and the ram, so preventing leakage even when the pressure is too low for the seal to react. The semi-circular section of the synthetic-rubber component presents a rounded surface to the fluid when in the stuffing box, thus ensuring that the fluid pressure can readily reach all parts of the exposed surface.

FLUID PRESSURE INCREASES SEALING FORCE

The fluid pressure exerts a force normal to the curved surface of the rubber filling. This force is transmitted by the rubber, and resultant forces act upon the synthetic-rubber impregnated lips of the U-piece, pressing them into intimate contact with the ram and the bore of the stuffing box. The force is dependent upon the fluid pressure, and consequently the interface pressure between the lips and the metal surfaces is roughly proportional to the pressure of the fluid, and always slightly in excess of it, so preventing leakage.

The seal needs no axial compression and a means of adjustment is therefore unnecessary, with consequent saving of space. In addition, the seal is able to operate successfully with considerable axial float, so that careful toleranicing or adjustment of the gland on fitting is not required. Since the seal is an integral unit the header ring, springs and other components usually necessary cannot be omitted inadvertently during fitting. And initial assembly and subsequent maintenance are thus simplified. It is also a comparatively easy matter to design a gland in such a way that it may be tightened down on to a face or shoulder, leaving a predetermined space in the stuffing box. The seal is thus protected from damage by over-compression.

The seal may be applied in a number of different ways and the choice depends upon the application. In drawing (*b*) the seal is shown fitted in a stuffing box to seal a reciprocating ram. This method of fitting is used for pump plungers, hydraulic-press rams, accumulators and similar hydraulic plant. In (*c*) the seal is shown fitted as a piston seal where the pressure acts on one side only. Employed in this manner the seal is suitable for hydraulic jacks, air brakes, aircraft landing gear, bulldozers, and other applications where in the past the cup-type packing has been used. Where the piston is double-acting and may be influenced by hydraulic pressure from either side, two seals should be fitted as shown in (*d*).



The "Hallprene" patent fluid seal comprises a U-ring of synthetic-rubber impregnated fabric bonded with a synthetic-rubber "nose," which fills the U-recess and serves in effect as a spreader ring (a). Particular applications of the seal are shown in (b), (c) and (d).

TESTS AND PERFORMANCE FIGURES

From independent tests it has been found that the friction of one seal at 100 lb. per square inch absorbs about 7 lb. per square inch, and at 1,000 lb. per square inch about 23 lb. per square inch, with intermediate points roughly linear. These figures do not take into account the weight of the moving parts and are intended only as an approximate guide to designers.

An interesting calibrated test on a rig for loading jacks was carried out with 21 jacks (some double-ended) varying in diameter from 3 in. to 5 in. These were fitted with standard Hallprene fluid seals on the pistons and square-section gland rings. The calibrations revealed that the maximum friction at 1,700 lb. per square inch was ± 3 per cent., that is a 3 per cent. variation from the theoretical value for the motoring and driving motions respectively. The average friction value for the 21 jacks calibrated was ± 2 per cent. at 1,700 lb. per square inch. The fluid used in these tests was Tellus 27.

A single fluid seal, 1 in. in diameter by $\frac{1}{2}$ in. by $\frac{3}{8}$ in., was fitted to the gland of a simple displacement liquid spring having a stroke of 1 in. The pressure variation from fully extended to fully closed was zero to 50,000 lb. per square inch. Failure due to separation of the rubber filler from the synthetic-rubber impregnated fabric U-piece occurred after 71,000 operations. It is reasonable to accept that such arduous conditions will require slight changes in production technique to overcome this separation, although the present life is sufficient for most purposes.

* * *

ANGLO-DANISH ATOMIC AGREEMENT

Britain to Help in Building Research Reactor

The United Kingdom Atomic Energy Authority and the Danish Atomic Energy Commission have settled the terms of an agreement for collaboration in a joint programme of research and development in the unclassified field of peaceful applications of atomic energy.

Under the terms of the agreement the Authority will assist the Commission in the design and construction of a high-flux research reactor of a type similar to one now being built at Harwell and will supply fuel elements for it. The agreement is for a period of ten years in the first instance and may be modified or extended at any time by mutual agreement.

* * *

LONDON'S MAIN DRAINAGE

Centenary Exhibition

Arrangements have been made by the London County Council to hold an exhibition, in commemoration of the centenary of London's main drainage service, at the County Hall, Westminster, S.E.1, from Saturday, July 16, to Friday, July 22. The general public will be admitted on the opening day from 10 a.m. to 7 p.m., and from July 18 to 22, inclusive, from 12.30 p.m. to 7 p.m.

The exhibition will cover the inception and development of the service, and sections will be devoted to introductory and historical aspects, sewage treatment and disposal, pumping plant, and sewers. The processes of drainage, pumping, sewage treatment, and the disposal of sludge at sea will be illustrated by the display of old documents, maps, diagrams, photographs, models and equipment, and there will be a number of film shows and lectures during the period of the exhibition.

EFFICIENT COAL UTILISATION

PROBLEMS UNDER REVIEW AT B.C.U.R.A.'S LABORATORY AT LEATHERHEAD

Once every three years, the British Coal Utilization Research Association hold an open day when they invite interested people to visit their premises at Leatherhead, Surrey, to inspect the research in progress. On June 8, 9 and 10 last, a series of demonstrations were given which covered the fields of chemistry, domestic appliances and industrial plant. At almost the same time, the Association published its annual report describing the work done in 1954.

Much work is being carried out on the chemistry of coal with particular respect to the problem of corrosion arising from its sulphur content. The mixing of coal and amines for making briquettes from slurry is another investigation which is under way and seems to have good prospects. A series of experiments which has only recently been started concerns the treatment of coal with chlorine trifluoride at temperatures of about 300 deg. C. and in an atmosphere of nitrogen. Under these conditions the coal is converted completely to volatile products which are claimed to have properties which may be of considerable importance in the future. Other work being done in this section concerns the classification and micro-structure of coals.

PULVERISING MILL

The physical properties of coal that are relevant to the breakage of coal during handling and during pulverisation, together with problems of particle-size distribution after pulverisation, are to be studied in a cone-type pulverising mill which has been developed and is illustrated in Fig. 1. In this, the coal falls on the point of the revolving cone and is thereby partly broken before passing under the peripheral balls. By re-circulating the coal, or by using a series of cones, particles can be produced with any chosen upper limit. The required number of passes required to produce a given degree of pulverisation can be deduced using matrix analysis. The mill has a high throughput and the prototype which was being demonstrated requires only about one thousandth of the driving power of some other types of grinding mill.

For the sampling of dust, several suction probes have been developed which feed small cyclones in which the sampled dust can be divided quite accurately into size ranges by varying the air flow rate. For measuring these sizes a technique has been produced in which a microscope slide with the dust sample on it is sprayed with aluminium (using a vacuum technique) and the sample then shaken off. The slide is then scanned mechanically by the microscope and the gaps in the aluminium layer left by the removed dust recorded photo-electrically. This method has the advantage that the result is not affected by the colour of the dust particles which might otherwise tend to give a false reading of the value of the illumination. The method is also far quicker than scanning the slide visually, and avoids human errors.

Suction pyrometers are other instruments that have been developed and were displayed. These can be used for temperatures up to about 1,900 deg. C. with very high accuracy. It is also possible to estimate the measuring error and so improve the final results. In one form the gas is sucked in the end of the probe and is cooled by water flowing at a known rate and the temperature rise of which is accurately measured. In another, the mass flow is measured by the pressure difference across the suction orifice, and the initial temperature deduced from the temperature on the cold side. The material of the probe is chosen to suit the operating conditions.

As regards the actual physical and mechanical properties of coal, a machine has been developed for determining Young's Modulus from the vibration of a very thin strip. It is illustrated in Fig. 2. By a series of cuts made in a certain way, strips of coal some four inches long and about half-an-inch wide have been produced which have a thickness of only a few thousandths of an inch. These are vibrated under controlled conditions and Young's Modulus determined from the measurements made. The strips fracture fairly quickly, but last long enough for accurate readings to be taken.

DOMESTIC HEATING

A great part of the work done on the domestic appliances section is concentrated, very naturally, on the open fire. Various models of free standing convector fires have been produced by different manufacturers to the general designs that have been developed by the Association. Details of one of these were given in ENGINEERING, page 469 *ante*. For testing the possibilities of small mechanical stokers, a sectional boiler with a capacity of 650,000 B.Th.U. per hour has been installed. This has been mounted on four load cells so that a continuous record of the weight can be obtained, from which accurate determinations of the rate of combustion can be made. The basic object of the tests, as in several other investigations being carried out, is the efficient use of small and low grade coal, of which much more is now being produced from the mines. Smokeless combustion is also being aimed at.

Central heating is often expensive and difficult to install in a house that has been built some time, so the Association have been developing a system which does not depend on gravity or thermal effects for circulation, but in which the water is circulated through small bore pipes by a small silent high-speed pump. The pipes, which may be less than 1 in. in diameter, feed standard radiator units, and have the advantage that, as the circulation is forced, they can be led inconspicuously around corners and over doorways. Thus structural work is avoided and also the subsequent redecoration. The pumps which were demonstrated were extremely small and almost completely silent; the various types are tested for noise in a special room. Automatic control is afforded by a by-pass valve which is governed by a thermostatic system, either direct or differential allowing for the external temperature. Other work being done in the domestic appliance section covers the heat emission of types of fire and the measurement of smoke emission.

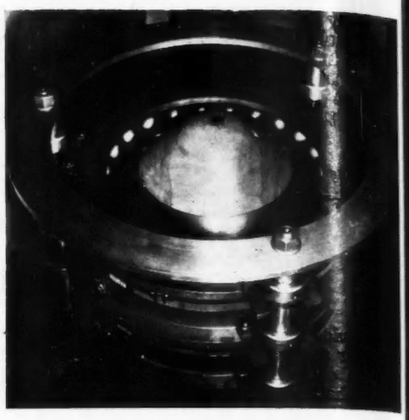


Fig. 1 In the cone mill that has been developed at B.C.U.R.A's laboratory coal is first broken by falling on the cone and then crushed by the balls. This mill requires only a fraction of the power needed for some standard types.

IMPROVED CHAIN GRATE

In conjunction with various other bodies, several projects concerning the firing of boilers are being investigated by the Association. One investigation has resulted in an improved chain grate which, by careful utilisation of the air supply can give the same heat release as a standard grate over a third longer. For comparison, the standard and the improved grates are shown in Fig. 3 on the opposite page. Supply arrangements to both are the same, but the long control damper in the modified grate and the reduced amount of ingited fuel are immediately apparent. The latter fact allows the grate bars to run cooler than in the standard version as the period of contact is not so long although the heat release is the same. Another advantage is that high-pressure air is not present below the ash, and therefore grit carry-over to the chimney is reduced to a large extent. The controlled air distribution allows low grade small coal to be used, as "funnelling" through the bed is checked. Experiments carried out during the 1954–5 heating season have given most satisfactory results using a wide range of coals. The variation of carbon dioxide produced from full load to minimum load was from 15 per cent. to 12 per cent., with a maximum burning rate of 65 lb. per square foot per hour.

LOCOMOTIVE STOKING

The questions of "funnelling" and the use of small coal also occur in another stoking problem under review. This concerns boilers for railway locomotives. To carry out the investigation, a "Royal Scot" type locomotive boiler has been installed and a three-year programme, in collaboration with the railway authorities, will shortly commence. A study has already been made of the gas-flow conditions in the firebox of the locomotive, which shows that rather less than half the grate area is effective due to the poor streamlining of the airflow in the

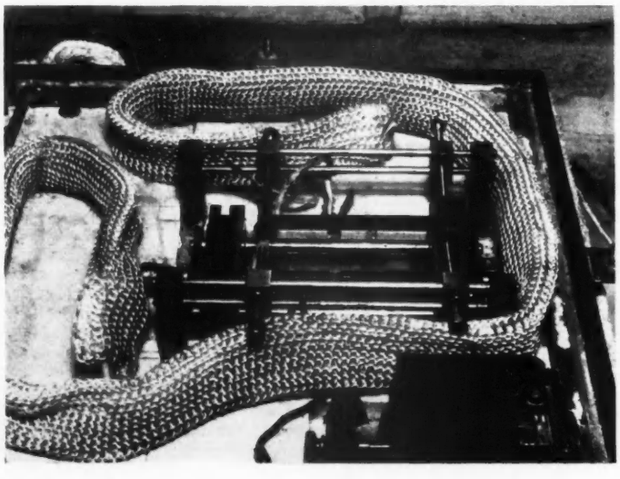


Fig. 2 Young's Modulus for coal can be obtained by determining the period of vibration of a strip a few thousandths of an inch thick.

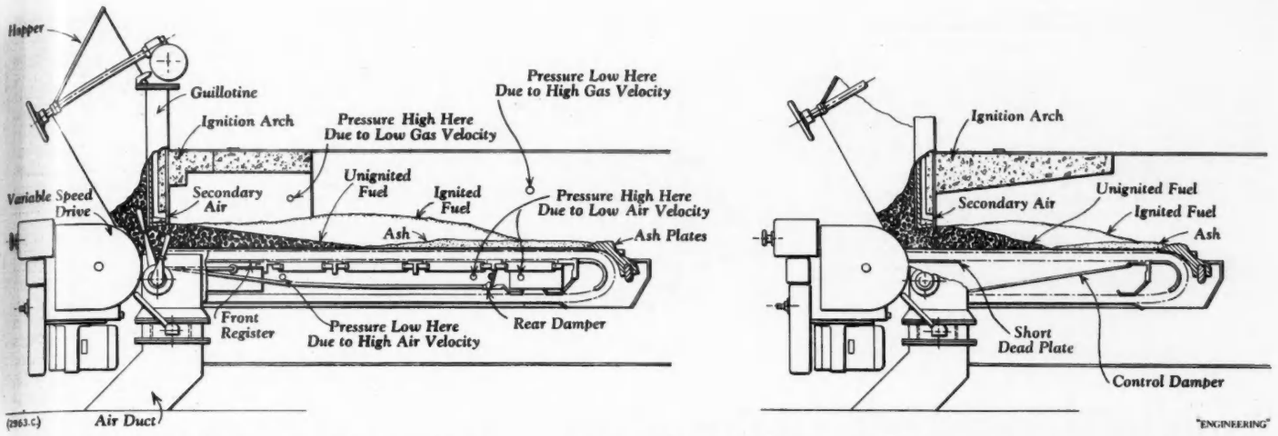


Fig. 3 By careful modification of the air flow below the bars, the length of the standard chain grate shown on the left has been reduced to that of the one on the right, while still giving the same heat release. The temperature of the bars, and the carry-over of ash into the chimney, have also been reduced.

ash pan. This is therefore the starting point of the investigations. At a later stage the possibility of installing mechanical stoking is to be investigated. Although some locomotives have been fitted with chain grates in the past, this would seem to have been merely in order to give a sufficiently high firing rate—higher than was possible by hand—rather than an attempt at combustion improvement.

Experiments are also in progress on an Economic boiler to determine the efficiency of a ram-stoker. These will be directly comparable with those for a chain grate that was used earlier with this boiler, and which have already been published. Other work deals with heat transfer and steam wetness.

PELLETS FROM SLURRIES

In order to make use of the slurry produced at collieries, a material notoriously difficult to handle, attempts have been made to form pellets which, when dried, form an easily handled fuel. For this object a machine has been developed to which the slurry is fed. It is first necessary, however, to ensure that the moisture content of the slurry is within certain definite limits or the operation is not successful. Within the limits allowed, however, the content controls the final size of the pellets produced. In the machine, the slurry first passes through a disintegrator which breaks it up before allowing it to fall on to an inclined oscillating tray. In the prototype machine which has a capacity of 1 ton per hour, this tray is 5 ft. long and 1 ft. wide. The bottom of it is formed into a large number of grooves running across the width, the action of which is to roll the particles of slurry into approximately spherical shape. To prevent the slurry from adhering to the tray, the surface is heated with hot air to between 120 and 150 deg. C. This also dries the pellets to some extent. The size of the pellets produced varies from about $\frac{1}{8}$ in. diameter to about $\frac{1}{2}$ in. They are strong enough to withstand a reasonable amount of handling. As a fuel, they burn well but have a low sintering temperature and their calorific value renders it economically necessary to avoid tranportation. They can, however, be used quite successfully for steam raising, and are rated considerably higher than wet slurries. This process of producing pellets is by no means limited to coal slurries: such substances as fly-ash and iron ores can be treated equally well.

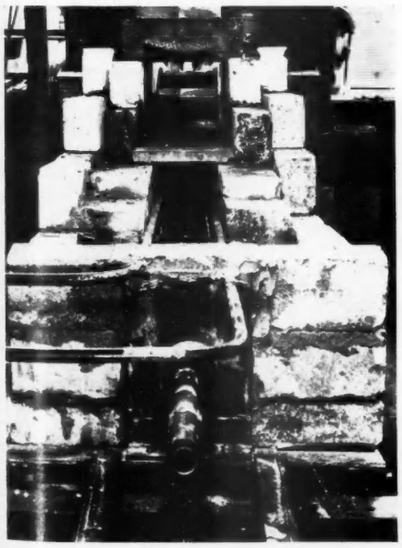


Fig. 4 Smalls and fines are indirectly heated at carbonising temperature and then formed into pellets for domestic fuel by the oscillating tray.

This method of making pellets has been extended to the production of carbonised agglomeration. Coal smalls and fines are fed into an indirectly-heated furnace of the type shown in Fig. 4 which has a grooved oscillating tray as its floor. The coal is rapidly heated to carbonising temperature (at a rate of about 20 deg. C. per second) and the major part of the volatile products driven off. This yields pellets of coke about 2 to 3 in. in diameter, containing about 15 per cent. volatile material, which make a good domestic fuel. Without a binder, however, the pellets are rather brittle. Their combustion is within the " smokeless " range.

The furnace is heated by jets of town gas which are separated from the carbonising furnace by slabs, as may be seen in the illustration.

Much work on gas producers is also being carried out by this section of the Association; in particular the evaluation of the gas itself, and the measurement of tar. A complete mobile laboratory has been developed for carrying out tests on industrial installations. It is equipped with instruments to record continuously the constituents of the gas; the instruments include infra-red absorption and thermo-conductivity types.

Among the investigations proceeding in the section which deals with furnaces, is one on the use of a cyclone combustor for high-ash crushed coal. This has been developed under an arrangement with the Department of Scientific and Industrial Research for research on the use of solid fuel for gas turbines, in particular for gas turbines at or near the pit head or where low-grade fuels can be utilised economically. The process can also be used for the direct firing of boilers. Considerable work is also being done on cyclone dust separators, down-jet burners and the whole problem of boiler deposits from pulverised fuels. These last are linked with the laboratory investigations mentioned earlier.

LAUNCHES AND TRIAL TRIPS

M.S. " SABANG."—Single-screw cargo vessel, with accommodation for a small number of passengers, built and engined by Eriksbergs Mek. Verkstads Aktiebolag, Gothenburg, for the Swedish East Asiatic Co., Gothenburg, Sweden. Sister ship of the M.S. Minikoi. Main dimensions: 445 ft. between perpendiculars by 62 ft. by 29 ft. to main deck; deadweight capacity, about 8,500 tons on a draught of 25 ft. 8 in.; cargo-carrying capacity, 540,000 cub. ft. (including 37,000 cub. ft. refrigerated space). Eriksbergs-B. and W. seven-cylinder single-acting two-stroke Diesel engine, developing 8,300 b.h.p. while operating on heavy-fuel oil. Service speed, 17 knots fully loaded. Launch, May 16.

H.M.S. " KILDARTON."—Twin-screw coastal mine-sweeper, built by Harland and Wolff, Ltd., Belfast, for the Admiralty, London, S.W.1. Main dimensions: 152 ft. by 28 ft. 9 in. by 14 ft. 9 in.; armament, three small guns. Diesel propelling machinery supplied by Mirrlees, Bickerton and Day, Ltd., Stockport, Cheshire. Launch, May 23.

M.S. " MANES."—Single-screw cargo vessel, built by the Burntisland Shipbuilding Co., Ltd., Burntisland, Fife, for the Compania de Navegacion Oriental de Panama S.A., Panama. Main dimensions: 435 ft. between perpendiculars by 61 ft. 9½ in. by 38 ft. 3 in. to weather deck; deadweight capacity, about 12,450 tons on a draught of 29 ft. Sulzer seven-cylinder single-acting two-stroke Diesel engine, developing 4,825 b.h.p. at 125 r.p.m. in service, on heavy-fuel oil. Launch, May 23.

M.S. " LOCH ARD."—Single-screw cargo vessel, with accommodation for a small number of passengers, built by Ferguson Brothers (Port-Glasgow), Ltd., Port-Glasgow, for David MacBrayne, Ltd., Glasgow. For service between the outer islands and the West Coast of Scotland. Main dimensions: 170 ft. by 34 ft. by 18 ft. 9 in. Six-cylinder Diesel engine constructed by British Polar Engines, Ltd., Glasgow, and installed by the shipbuilders. Speed, 12 knots. Launch, May 23.

M.S. " NAVUA."—Single-screw cargo vessel, built by Henry Robb, Ltd., Leith, for the coastal services of the Union Steam Ship Co. of New Zealand, Ltd., Wellington, New Zealand. Main dimensions: 250 ft. between perpendiculars by 41 ft. 6 in. by 17 ft. 9 in. to upper deck; deadweight capacity, about 2,000 tons on a mean draught of 16 ft. Clark-Sulzer five-cylinder two-stroke Diesel engine, developing 1,500 b.h.p. at 225 r.p.m., constructed by George Clark (1938), Ltd., Sunderland. Speed in service, 11 knots. Delivered approximately two months ahead of contract date. Trial trip, May 24.

M.S. " KARMT."—Single-screw oil tanker, built by the Furness Shipbuilding Co., Ltd., Haverton Hill, County Durham, for H.M. Wrangell & Co., Haugesund, Norway. Second tanker constructed for these owners. Main dimensions: 525 ft. between perpendiculars by 71 ft. by 39 ft. 3 in.; deadweight capacity, about 18,100 tons on a summer draught of 30 ft. 5¾ in.; oil-tank capacity, about 17,000 tons. Hawthorn-Doxford six-cylinder single-acting two-stroke reversible oil engine, developing 6,600 b.h.p. at 115 r.p.m. in service, constructed by Hawthorn Leslie (Engineers) Ltd., Newcastle-upon-Tyne. Speed, 15 knots. Launch, May 24.

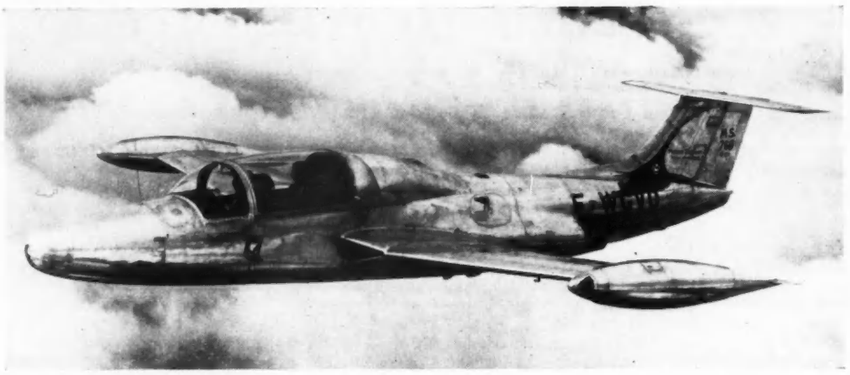


Fig. 1 The Morane-Saulnier Paris, a four-seat liaison twin-jet aircraft which is to be built under licence by Beech Aircraft Corporation in the U.S.A., where it is now on a demonstration tour.

FRENCH AIRCRAFT DEVELOPMENTS

THE LIGHT JET MACHINES

During the past week the 21st Salon International Aéronautique has been in progress at le Bourget airport, Paris. Organised by the Union Syndicale des Industries Aéronautiques, it has provided an opportunity for observing the progress made by the French aircraft industry, which has, as Air Commodore F. R. Banks has suggested recently, been undergoing a renaissance within the last few years.

At the 1953 Salon Aéronautique International, three of the exhibits which most impressed foreign visitors were the light-weight Turboméca-powered jet machines—the SIPA 200 civil light training aeroplane and the two rival military jet trainers, the Fouga Magister and the Morane-Saulnier Fleuret. Each of these companies has made excellent progress in the succeeding two years and to-day it is probable that France leads the world in this field.

SIPA 300 LIGHT JET TRAINER

Société Industrielle pour l'Aéronautique, Place Eugene Sue, Suresnes (Seine), have followed up the SIPA 200 Miniget, which " stole the show " in 1953, and of which seven have been ordered by the French Air Force, with the SIPA 300, an all-metal tandem two-seat trainer (Fig. 2).

The SIPA 300 is, like the S200 Minijet, powered by a Palas turbojet developing 350 lb. static thrust. Whereas, however, the Minijet has twin tail booms and a nacelle-type cockpit in which pupil and instructor are seated side by side, the S300 has a conventional fuselage with two cockpits, the forward accommodating the pupil pilot and the rear cockpit accommodating the instructor. The engine is installed aft of the rear cockpit and has air intakes in the wing roots.

The wing, of single spar construction, is of laminar section, trapezoidal in plan. In the centre section wing, which is carried across the fuselage, are a 15·5-gallon fuel tank, which serves for inverted flight, and the wheel recesses for the main undercarriage wheels. Double-slotted flaps and slotted ailerons are fitted. The elevator has a trim tab adjustable in flight from either cockpit.

The rear fuselage is of conventional stressed-skin construction. Each of the cockpits has an individually jettisonable Plexiglas hood. As already mentioned, the Palas engine is installed in the rear fuselage and is readily accessible through the bottom fuselage panel, which is detachable. Above the engine is mounted the main 33-gallon fuel tank and also the hydraulic fluid reservoirs. The lubricating oil tank is in the engine compartment forward of the fire-proof bulkhead. The entire front cone of the fuselage forward of the front cockpit can be detached to give access to the radio equipment which comprises a three-channel V.H.F. transmitter/receiver set.

The wing flaps and retractable tricycle undercarriage are hydraulically operated, pressure being supplied by an engine-driven pump. An emergency hand-pump can be operated from the forward cockpit only in the event of failure of the main system. The wheel brakes are also hydraulically operated and are supplied from a separate reservoir. The electrical services—radio, instruments and indicators, and engine-starting services—are supplied by a 28-volt 600-watt generator and a battery, grouped on the left of the fuselage aft of the pilot, the control panel being on his right.

The SIPA 300 has a span of 26·5 ft. and a wing area of 104 sq. ft. The overall length of the aircraft is 22 ft. and the height 8·25 ft. The weight empty is 1,150 lb. and the maximum fully-loaded weight is 1,970 lb. The maximum speed at sea-level is 225 m.p.h., the sea-level cruising speed 195 m.p.h., and the landing speed 56 m.p.h. The maximum sea-level rate of ascent is 1,120 ft. per minute on take-off power and 690 ft. per minute on cruising power. The aircraft will climb to 1,200 ft. in about 1·6 minutes and to 16,400 ft. (approximately the practical ceiling) in 39 minutes. The SIPA 300 will take-off and clear a 50-ft. obstacle within 670 yards and will land over a 50-ft. obstacle in 300 yards. The maximum duration is 1 hour 20 minutes.

MORANE-SAULNIER PARIS 4-SEAT JET AIRCRAFT

Although the Morane-Saulnier Fleuret, which is again appearing at the Salon, was not successful in securing the French Air-Force contract for the light jet trainer—this went to the Fouga Magister—it aroused very wide interest both in France and abroad, on account not only of its flying performance but also its excellent " design for maintenance." From this machine Société Morane-Saulnier, 3 and 5, Rue Volta, Puteaux, Seine, have developed the M.S. 760 Paris four-seat twin-jet liaison aircraft (Fig. 1), which has achieved the distinction of being the first foreign jet aircraft likely to be constructed under licence in the United States, by the Beech Aircraft Corporation, Wichita, Kansas.

On account of this agreement, the M.S. Paris is not on view at the Salon. It has been shipped to the United States, where it is engaged on demonstration flights. It will not be out of place, however, to include a brief description in this article. The wings, rear fuselage, tail surfaces and engine installations are identical with those of the Fleuret, which was described in our July 10, 1953 issue (vol. 176, page 43). The front part of the fuselage has been modified to take two more, passengers and permanent wing-tip tanks have been added which give an additional 83·5 Imperial gallons fuel capacity. Fuel from the wing-tip tanks is transferred to the main fuselage tank, which holds 215 gallons, by compressed air from the engine compressors.

As in the Fleuret, accessibility for maintenance is one of the primary virtues of the Paris; for instance, the entire rear fuselage can be rapidly detached to give access to the two 883-lb.-thrust Marboré jet engines, which are installed aft of the cockpit. The latter is pressurised by air supplied from the engine compressors, and is air-conditioned by controlling the flow of air through a heat exchanger and an expansion turbine.

The elevator and aileron trim tabs, split flaps, dive brakes (fitted on the wings) and undercarriage are all electrically operated, power for the electrical services and radio being supplied by a 24-volt 2,500-watt generator and a 35 amp.-hour battery. Two 12-channel V.H.F. radio sets and a radio compass are provided.

The wing span is 31 ft. 4 in., the overall length is 32 ft. 11 in., and the height is 8 ft. 6 in. The wing area is 194 sq. ft. The empty weight of the aircraft is 3,820 lb. and the maximum permissible weight is 7,500 lb., allowing the carriage of full fuel and three passengers with 66 lb. of baggage each. At this weight the aircraft requires a take-off run of about 800 yards. The landing speed is 96 m.p.h., and the maximum speed is 405 m.p.h. The sea-level rate of climb is 2,280 ft. per minute, falling to 780 ft. per minute at 23,000 ft., the latter height being attained from sea level in 18 minutes. Cruising at 23,000 ft. at maximum continuous r.p.m., the still-air range is 930 miles at an average speed of 340 m.p.h. The critical Mach number is 0·72.

FOUGA MAGISTER TRAINER

The Fouga company have been notably successful in expediting the production of the

Fig. 2 The SIPA 300 light jet trainer, of all-metal construction, has cockpits in tandem. Powered by a 350-lb. thrust Turboméca Palas jet engine, it cruises at 195 m.p.h.

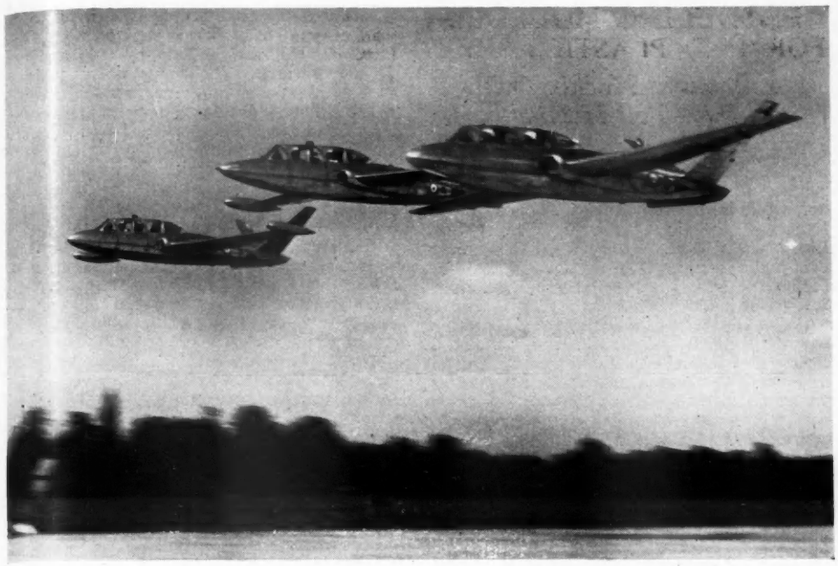


Fig. 3 Three Fouga Magisters in flight. These twin-jet military trainers are in production for the French Air Force.

CM 170R Magister light jet trainer, which has been ordered in quantity by the French Air Force and has been recommended by the N.A.T.O. air-training advisory group as being the most suitable aircraft available for basic and intermediate military training. The contract for the first prototype was signed on June 27, 1951, and less than 13 months later the aircraft made its first flight. After evaluation by the French Air Force, a pre-production contract for 10 aircraft was placed on June 2, 1953, and the first pre-production Magister flew on July 7, 1954. In January, 1954, an order was placed for 100 Magisters. To-day, the ten pre-production Magisters have been completed and a production line has been set up at the company's new assembly plant at Toulouse-Blagnac.

The Magister, designed and constructed by Fouga et Compagnie, 90 Rue de Miromesnil, Paris, was described in the July 10, 1953, issue of ENGINEERING (page 42, vol. 176). Briefly, it may be recalled that, like the M.S. Fleuret, it is an all-metal midwing monoplane powered by two Turboméca Marboré jet engines. The aircraft is pressurised and air conditioned, but it has a tandem seating arrangement. This appears to have gained favour for military training because the pupil is from the first made familiar with the single-seat cockpit and instrument layout, and because he is located on the aircraft centre-line as he would be in a fighter aircraft—an important consideration for training in aiming and in formation flying. An excellent view for the instructor in the rear cockpit is ensured by a periscopic binocular specially designed for the Magister. The aircraft has an unconventional butterfly-tail arrangement, characteristic of Fouga designs (Fig. 3).

The aircraft is equipped with two 7·5 mm. guns and a camera gun; it can carry four 25-kg rocket projectiles and two 50-kg bombs. The radio equipment comprises two V.H.F. sets, a radio compass and an intercommunication system. Full blind-flying instrumentation is provided. The normal fuel capacity, in two fuselage tanks, is 160 Imperial gallons; two wing-tip tanks provide an additional capacity of 28·5 gallons each.

At a take-off weight of 6,280 lb., without tip tanks or external stores, the Magister will take off and clear a 50-ft. obstacle in 870 yards, and will climb to 30,000 ft. in 16 minutes. The maximum speed at sea level is 423 m.p.h. and at 30,000 ft., 444 m.p.h. The duration, with a reserve of 27 gallons of fuel, is 1 hour 55 minutes. The limiting Mach number is 0·82.

It is of interest to record briefly the principal modifications incorporated in the production aircraft. The authorised load factor has been increased from 4·5 *g* to 5·5 *g*. The air-brakes, on the upper and lower wing surfaces, have been redesigned to reduce vibration, and trailing-edge fences have been fitted between the air-brakes and the ailerons to eliminate air-brake interference on aileron effectiveness. Boundary-layer bleeds have been incorporated in the engine air intakes and the ducts have been enlarged and straightened. Leading-edge slots have been added to improve the stalling characteristics and give a pre-stall buffet warning.

The air-conditioning has been improved by the addition of a cold-air turbine and provision for selecting hot or cold air for the cockpits, and windscreen de-icing. An independent cabin air inlet has also been provided. Synchronised gun sights are now provided for both pilots and it is possible to fire guns, rockets or bombs at a speed of 460 m.p.h. All the instrumentation on the production Magister will be of the most recent design and of French manufacture, and the cockpit layout has been improved. The fuel consumption of the Marboré engine has been lowered as a result of engine modifications. Maintenance facilities have been improved by better accessibility, the number of inspection panels has been greatly increased, and connectors for auxiliary electric, hydraulic and pneumatic power supplies are now of the standardised N.A.T.O. type.

To be continued

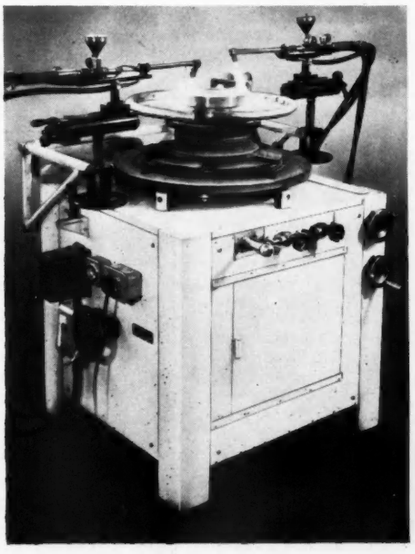
* * *

DEPOSITION OF HARD-FACING ALLOYS IN POWDER FORM

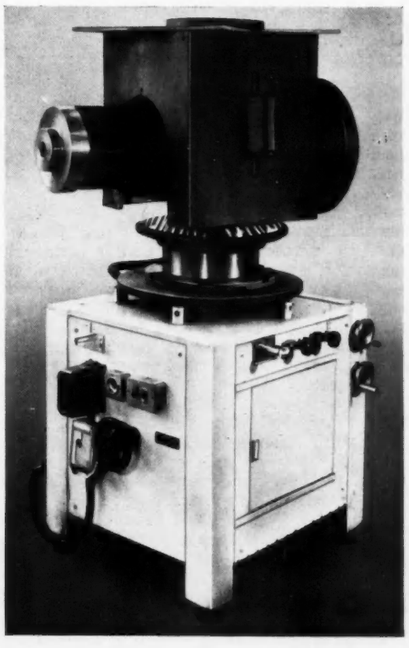
Automatic Machine and Manual Methods

A process for the deposition, in powder form, of hard-facing alloys, namely, alloys possessing heat, wear, and corrosion resisting properties, has been developed by Dewrance and Company, Limited, Great Dover-street, London, S.E.1. This, the T.L.B. process, so called from the initials of the surnames of the three American originators, Mr. F. N. Taylor, Mr. A. Long, and Mr. A. Blacklock, employs a standard oxy-acetylene welding torch into which has been incorporated a small metal-powder hopper, powder-control valve and powder nozzle. In operation, powdered metal is drawn from the hopper through the powder-control valve, into the gas stream passing through the torch and flows with the gas mixture to the welding nozzle. The metal powder is heated as it travels through the flame and is melted by the time it reaches the base or parent metal, thus producing a satisfactory bond.

The metal powders used consist of pure alloys which may contain chromium, cobalt, nickel, molybdenum and iron; nickel, chromium, tungsten and cobalt; or nickel silicon and boron. The last alloy melts at about 1,100 deg. C., and the first two at about 1,300 deg. C. Alternatively Stellite, Colmonoy or any other



Annular-facing welding machine, showing two oxy-acetylene torches fitted with metal-powder attachments being used for hard-facing a valve disc on the turntable of the machine.



Hooded high-pressure high-temperature steam-valve body being pre-heated by gas jets on the turntable of the machine prior to the deposition of a hard-facing alloy on the valve-seat faces.

powdered hard-facing material may be employed, and brasses, bronzes, copper and other metals can also be readily deposited. No flux is used and the metal powder is of a degree of fineness which will pass through a British Standard 410 : 1943 No. 120 sieve. This has an aperture width of approximately 0·0050 in.

The flame adjustment and pre-heating of the work depend, of course, on the base material and on the composition of the metal or alloy being deposited, but steel components are usually preheated to a temperture of about 1,000 deg. F. The finished deposit is much smoother than that accomplished by the conventional filler rod and welding-torch method. Deposits of up to ¼ in. thick in a single run are regularly achieved and, where necessary, a second deposit can be run on the top of the first. The thickness of the deposit is always under control, thereby effecting a saving in the amount of material used and reducing subsequent machining and grinding operations to a minimum. The Vickers diamond-pyramid hardness number of the nickel-silicon-boron alloy deposit is given as about 700-750 and that of the other two alloys mentioned above approximately 400-450.

Not only is the process appreciably quicker than the conventional rod method but there is no need to employ skilled welders. Intelligent labourers can be quickly trained to do the work, and, moreover, the process lends itself to automatic or semi-automatic operation. In enclosed spaces or places difficult of access this is an obvious and distinct advantage.

AUTOMATIC DEPOSITION

The annular facing welding machine shown in the two illustrations on page 773 has been designed and produced by Messrs. Dewrance specially for use with the T.L.B. metal-powder deposition technique. In that on the left two torches with their powder attachments and hoppers are seen effecting a deposit of hard-facing material on the flat annular surface of a valve disc. The machine is a self-contained unit of robust construction with controls for regulating the speed of rotation of the table, the mixture of oxygen and acetylene, and the elevation and traverse of the torch nozzles. A lever puts a clutch system in operation to start or stop the rotation of the table. An independent motor and mechanism provide the reciprocating motion for depositing metal from side to side of the annular surface and the throw of the crank can be suited to the width of the surface.

In the illustration seen on the right, an alloy-steel high-temperature, high-pressure steam valve weighing some 30 cwt. is shown on the turntable of the machine. The valve body is being pre-heated by means of gas jets prior to the deposition of hard-facing alloy on the seat faces. The valve is covered by a hood to conserve the heat, which can be regulated to maintain the required temperature during the deposition operation and also to stress-relieve the casting after the deposition operation. In steam valves of the type shown the deposition of metal is carried out by a single central torch inclined at the requisite angle relative to the work. Large steam valves, weighing over two tons, may be treated on the machine and the operation completed quickly and smoothly.

The process lends itself to numerous applications other than those connected with steam-valve work. Thus, internal-combustion engine inlet and exhaust valves have been treated and a nickel-silicon-boron hard-facing coating has been deposited on En. 53 and 54 valve steels. The valves have been tried in service and, it is stated, have been found entirely satisfactory. Rocker arms for fuel pumps, various locomotive components, and other articles have been given hard-facing deposits and a particularly interesting example is that of a large gunmetal slide valve on which an austenitic nickel-base hard-facing layer has been deposited. In spite of the difficulties due to the similar melting points of the deposit and the base alloy, a good machined face has been obtained and the slide valve is now undergoing service trials.

PRODUCING MOULDED FORMS IN PLASTICS SHEET

Automatic Machine with Infra-Red Heating

One method of moulding plastics sheet into the required shape is by a technique known as vacuum forming. An automatic machine for doing this has recently been introduced by the Latymer Engineering Company, 27 Charles-street, London, S.W.13, and was on show at the recent British Industries Fair on the stand of Bakelite, Limited, 12–18 Grosvenor-gardens, London, S.W.1. It is illustrated below.

The process of vacuum forming is based on two simple facts. First, that if a vacuum is created on one side of a sheet of material which is impervious to air, the atmosphere will exert pressure on the other side. Second, that certain types of plastics sheet soften on the application of heat and can then be formed into shapes which will be retained when the sheet cools and regains its rigidity. So, if a sheet of heat-softened plastic can be forced by atmospheric pressure against a form moulded in relief, and then the mould removed when the sheet has cooled, it will reproduce exactly the shape and detail of the mould.

In the automatic machine the required mould is placed in the mould box, and the two process timers, one controlling the movement of the heater and the other the period during which the vacuum valve remains open, are set according to the type of mould and material being used. The height of the heater can be adjusted to control the amount of heat directed on the sheet. The plastics sheet is then clamped in the frame and the automatic cycle started. The heater travels forward, rests for the pre-set period (usually from 10 to 30 seconds, according to the thickness of the sheet) and returns to its original position. Another electrical circuit is then set in operation, opening the valve into the vacuum tank. The air in the moulding box, below the plastics sheet, is immediately drawn into the tank, creating a vacuum in the box and drawing the softened sheet down over the mould. The valve then closes and the cycle is complete. A blast of air from an air line assists the cooling of the sheet, and the formed article is removed.

Very intricate detail can be reproduced in this way, as well as deep-drawn formations, and many small parts can be produced on one sheet for subsequent cutting. The moulds themselves can be made rapidly and economically from metal, wood or even plaster. The sheet can also be colour printed in distortion from a prototype moulding which has been first painted and then re-flattened.

The Latymer machine has overall dimensions of 2 ft. 6 in. wide by 5 ft. long by 4 ft. high. The blanket-type heater, which runs on fibre rollers fitted with ball races, is 25 in. by 27 in. and has a 3½ kW loading. The heavy ribbed platen is cast in aluminium and incorporates clamping holes at 2-in. intervals, and the height between heater and platen can be varied by means of a capstan-type handwheel.

An easily-adjustable clamping frame for the sheet is secured by a cam-action toggle clamp and balanced by two weights. The pump is a rotary machine driven by a ½-h.p. motor. The vacuum receiver consists of a galvanised cylinder 18 in. diameter, 30 in. long and ⅛ in. thick. Evacuation is controlled by two valves; a quick-action type for thin material and the reproduction of small detail, and a slower-action type for deeper drawing and thicker material.

The control panel carries pilot lamps for the heater and motor circuits, and the process timers for the heater and vacuum. When the required settings have been made, a single push-button control puts the whole cycle into operation.

Moulded forms are produced in this machine by applying a vacuum to one side of a plastics sheet so that atmospheric pressure forces it down over a pattern or mould.

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ALUMINIUM DAMP COATING

An anti-corrosion coating containing aluminium pigment has been produced by Xzit (G.B.) Limited, 175 Piccadilly, London, W.1. This is in the same range as their black "Serviron" coating which is self-healing and non-toxic. The aluminium Serviron has all the properties of the original material, with the advantage of the bright colouring. It can be sprayed or brushed.

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MAGNETS USED FOR UNPACKING CARTONS

For unpacking metal or metal-capped containers from the cartons in which they have been received, a magnetic device, held in the hand, has been produced by Rapid Magnetic Machines, Limited, Lombard-street, Birmingham, 12. It consists of a plate with a central handle and of a size to cover the carton, in which magnets are fitted in positions corresponding to the containers. A second plate, held to the first with springs, has holes through which the magnets can be protruded to make contact with the containers. When the batch has been lifted out and placed on the table or conveyor, compression of the two parts of the handle separates the plates, thereby withdrawing the magnets, and dislodging the containers. As all parts other than the magnets are made of aluminium, the device is very light and truly portable. It can be made to suit the needs of any particular operation.

Fig. 1 The Quoich dam, which forms part of the Garry-Moriston scheme of the North of Scotland Hydro-Electric Board, under construction. When finished the dam will be the height of the valve tower on the right.

WATER POWER IN SCOTLAND

I.E.E. SUMMER MEETING

Although it at one time appeared that it might have to be cancelled owing to the railway strike, the Summer Meeting of the Institution of Electrical Engineers took place in Scotland from Monday, June 6, to Saturday, June 11. Nearly 500 members and ladies attended and among those present were the President (Mr. J. Eccles), the chairman of the Scottish Centre (Mr. J. S. Hastie), and several Members of Council. The *leit motif* of the visit was the inspection of a number of the water-power schemes of the North of Scotland Hydro-Electric Board, some of which are in operation and others under construction.

DETAILS OF PROGRAMME

Members assembled in Glasgow on Monday evening, June 6, when they were received by the Lord Provost and Magistrates in the City Chambers. The next day the journey continued to Inverness by coach, inspections being made *en route* of the Loch Sloy station of the North of Scotland Hydro-Electric Board and the Fort William works of the North British Aluminium Company. In the evening a talk on the projects to be visited was given by Mr. T. Laurie, general manager of the North of Scotland Hydro-Electric Board.

On Wednesday and Thursday, June 8 and 9, visits were paid to the Conon Valley, Glen Affric and Garry-Moriston schemes of the Board, and on the evening of the first of these days there was a reception by the civic authorities of Inverness. On Saturday, June 11, the party journeyed by coach to Edinburgh and Glasgow, the Clunie and Pitlochry stations being inspected *en route*.

The Loch Sloy,* Conon Valley,† and Glen Affric‡ schemes, as well as the Fort William,§ Clunie and Pitlochry‖ stations, have already been described in ENGINEERING. It will therefore be sufficient to say that the Loch Sloy station, which is mainly used to supply peak loads, contains four 45,500-h.p. sets, which operate under a net head of 810 ft. The alternators of these sets are connected through transformers to an outdoor switching station at Inveruglas. The first machine went into commercial service in March, 1950.

The Conon Valley scheme in Ross-shire is being carried out in three stages, the first of which, comprising a 24-MW station at Grudie Bridge and its associated works, was also completed in 1950. The second stage involves the construction of power stations at Glascarnoch (24 MW), Achawalt (2 MW), Luichart (24 MW) and Torr Achilty (15 MW). Of these, the Luichart and Torr Achilty stations are now running, while the remainder are still under construction. The third stage upon which work has hardly begun comprises a power station at Ackonokie, with its associated civil engineering works.

GLEN AFFRIC

The Glen Affric scheme comprises two dams at Benevean and Mullardoch, the latter containing a 2,400-kW power station in which the compensation water is used. The reservoirs thus formed are connected by a 3½-mile tunnel and water is taken from Benevean through a second tunnel of the same length to a generating station at Fasnakyle. This station contains three 33,000-h.p. sets, which operate under a gross head of 522 ft. and are connected through transformers to the 132-kV system.

The Fort William works of the North British Aluminium Company make use of the waters of Loch Treig and Loch Laggan, which flow through a 15-mile tunnel driven under Ben Nevis to a station containing twelve 10,000-h.p. impulse turbines. These turbines are coupled to 7,000-kW direct-current generators, the total current output of which is no less than 280,000 amperes. During the visit it was possible to see the works of the British Aluminium Company at Foyers, on Loch Ness, which came into operation in 1896 and comprised the first major hydro-electric scheme in the country.

The Clunie and Pitlochry stations both form part of the Tummel-Garry scheme. The former contains three 27,200-h.p. turbines operating at a head of 173 ft. and the latter two 10,900-h.p. Kaplan sets with a head of 42½ to 47 ft. Both stations are controlled from switchgear at Clunie, the output being transmitted at 132 kV to Errochty switching station, which is equipped with 14 2,500-MVA shunt-arc circuit breakers. At Pitlochry there is a fish ladder with glass panel observation chambers where fish may be seen ascending and sometimes descending.

THE GARRY-MORISTON SCHEME

The Garry-Moriston scheme is designed to make use of the water resources of 300 square miles north-west of the Great Glen and thus to assist the future industrial development in the Inverness and Fort William areas, as well as in the rest of the Highlands. The total output will be about 380 million kWh per annum.

The civil engineering works of the Garry portion of the project consist of a dam, 1,000 ft. long and 122 ft. high, which is being built across the Gearr Garry at the eastern end of Loch Quoich. This dam is shown in course of construction in Fig. 1, with the first sections of concrete facing on the top of the masonry nearing completion. When finished it will be the height of the valve tower on the right. From the reservoir thus formed water will be led down 320 ft. to a 22-MW station from which water will be discharged into Loch Poulary on the

Fig. 3. Underground power station at Ceannacroc showing the loading bay from the access tunnel.

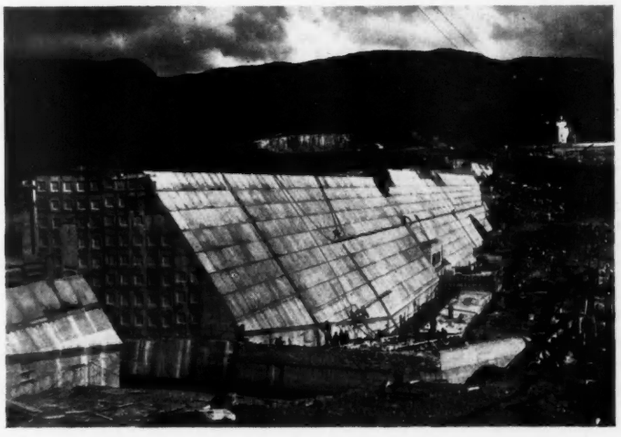

Fig. 2 General view of the Clunie dam looking north.

* Vol. 170, pages 1 *et seq* (1950).
† Vol. 172, pages 65 *et seq* (1951). Vol. 177, page 90 (1954). Vol. 178, pages 629 *et seq* (1954).
‡ Vol. 174, pages 457 *et seq* (1952).
§ Vol. 130, pages 610 *et seq* (1930) and vol. 147, pages 329 *et seq* (1939).
‖ Vol. 170, pages 425 *et seq* (1950).

River Garry, A second dam is being built at the eastern end of Loch Garry and from the resulting reservoir, water will be led to a 20-MW station operating under a maximum head of 175 ft., which will be situated at Invergarry near the outlet of the River Garry at Loch Oich, in the Great Glen.

The Moriston project will include the construction of a dam across the River Moriston, thus raising the level of Loch Loyne. The water thus impounded will be conveyed by tunnel and pipe line to Loch Cluanie. The level of this loch will be raised by a second dam, which is shown under construction in Fig. 2 and will be 2,234 ft. long and 118 ft. high. This is one of the dams in the construction of which Trief concrete and pre-cast facing blocks are used. From the reservoir thus formed the water will be conveyed by a second tunnel and a pipe line to a 20-MW underground power station near Ceannacroc Bridge. The walls of this station will not be rendered, it being intended to employ a natural rock finish. A view from the access tunnel into this station showing the loading bay is given in Fig. 3.

Since the scheme received Parliamentary sanction in 1949 a small reservoir in lower Glen Moriston and a power station at Dundreggan have been abandoned. But the dam at Dundreggan, to form a larger reservoir, is being constructed and an underground power station is being built at its base. The turbines in this station, which will take the place of the station which was to have been built at Invermoriston, will discharge into a tunnel leading to Loch Ness. A subsidiary station with a capacity of 3 MW will also be built above the Dundreggan dam and its turbines will discharge into the new reservoir. As a result of these modifications it has been possible to save about 1,400 tons of steel and 25,000 tons of cement.

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NOTICES OF MEETINGS

Institute of Petroleum

LONDON

Symposium on "The Story of the Co-ordinating Research Council of the United States," comprising "The Development and Aims of the Co-ordinating Research Council," by M. K. McLeod; "Current Projects of the Council," by T. B. Rendel; "What the Council Means to the Automotive Industry," by E. S. MacPherson; and "What the Council Means to the Petroleum Industry," by W. J. Sweeney. Meeting arranged in co-operation with the Council. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Thurs., June 30, 3.30 p.m. and 5.30 p.m.

Institute of Physics

GLASGOW

Summer Meeting, Non-Destructive Testing Group. Royal Technical College, Glasgow. Wed., June 22, to Sat., June 25. Assembly, Wed., June 22, 8 p.m.

Annual General Meeting; "Training for Radiography," by T. S. Wylie; "Shipyard Radiography," by E. J. Duffy; and "Non-Destructive Testing in the Boilermaking Industry," by W. G. Marskell, at 9 a.m. "Surface Properties: Their Possible Use in the Testing of Materials," by Dr. R. W. B. Stephens; and "The Physical Meaning of Indentation and Scratch Hardness," by Dr. D. Tabor, at 2.15 p.m. Supper at 7.15 p.m. Thurs., June 23.

"An Assessment of Ultrasonic Techniques, with Special Reference to Welds," by H. L. Carson; and "Problems in the Interpretation of Ultrasonic Tests on Steel," by I. M. MacKenzie and R. Kennedy, at 9.15 a.m. Works Visits and Evening Excursion, from 1.30 p.m. onwards. Fri., June 24.

"Neutron Radiography," by Dr. J. Thewlis and R. T. P. Derbyshire; and Discussion on "Research Work Required to Promote Progress in the Field of Non-Destructive Testing," opened with a paper on "The Scope of Non-Destructive Testing," by Dr. E. G. Stanford. Sat., June 25, 9.30 a.m.

Royal Sanitary Institute

DURHAM

Various papers, including "The Durham Towns: Their Economic and Social Significance," by A. V. Williams. Durham Sessional Meeting. Shire Hall, Durham. Fri., July 1, 10 a.m.

Women's Engineering Society

LONDON

Annual General Meeting. Hope House, Great Smith-street, S.W.1. Wed., June 22, 7 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Institute of Petroleum, Manson House, 26 Portland-place, London, W.1. (LANgham 2250.)
Institute of Physics, 47 Belgrave-square, London, S.W.1. (SLOane 9806.)
Royal Sanitary Institute, 90 Buckingham Palace-road, London, S.W.1. (SLOane 5134.)
Women's Engineering Society, 45 Eastcastle-street, London, W.1. (LANgham 9371.)

Labour Notes

RAIL STRIKE CONTINUED

Widespread disappointment will be felt that the railway strike has been allowed to drag on. In spite of almost continuous discussions between the parties to the dispute, and of the intervention of Sir Walter Monckton, the Minister of Labour, the strike has extended well into its third week and, as recently as Tuesday morning, there seemed to be little likelihood of the members of the Associated Society of Locomotive Engineers and Firemen returning to work immediately, although the prospects were distinctly brighter.

The long-drawn-out negotiations appear to have started from a fresh angle as long ago as Wednesday of last week and, by last Tuesday, there were signs that some progress had been made, although it was also apparent that one or two substantial difficulties remained.

In his statement to the House of Commons last Monday, Sir Walter said that it would be undesirable to debate the circumstances of the strike, the negotiations in respect to it being then in a "critical stage." He informed the House that the immediate purpose of the discussions was to find a basis on which the enginemen could return to work, so that negotiations between the parties might be resumed in a strike-free atmosphere.

One of the greatest difficulties confronting the Minister's efforts at conciliation has been that representatives of the National Union of Railwaymen have not been allowed to take part in the talks between the A.S.L.E.F. and the British Transport Commission. The failure to reach agreement on this point seriously hampered a settlement of the dispute and seems to have lost the A.S.L.E.F. some of the sympathy originally felt for its cause. The joint meeting of all three parties on Tuesday was a big step forward.

NO NEW DOCTRINE

The Prime Minister's broadcast speech on June 5 about the railway strike raised some doubts in the minds of the Opposition as to his attitude towards a return to work and the re-opening of discussions.

Sir Anthony had said that the Government wanted to get talks going between the parties, and that once negotiations were resumed the board of conciliation would have its part to play. That offer still stood. The board would be ready to help in discussions the moment work began.

The matter was raised in Parliament on June 9 by Mr. C. R. Attlee, who declared that the Prime Minister, perhaps by inadvertence, had put forward a new doctrine that no negotiations should take place without a return to work by the strikers. He said that that line had been taken, and rightly so, with unofficial strikers, because it was essential that the authority of the unions should be supported but it had certainly not been put forward as a general proposition.

Mr. Attlee invited the Prime Minister to correct what appeared to many people to be setting out a new doctrine, which, if persisted in, would lead to an aggravation and lengthening of industrial disputes.

In his reply, Sir Anthony denied that any new doctrine had been laid down. He said that he accepted what Mr. Attlee had said about misapprehension but he hoped that it would be clear that it was never in his mind that there could not be discussions or conversations of all sorts before work was resumed. There must be. So far as the railway strike was concerned, they were going on at that moment.

DANGERS OF INDISCIPLINE

Further warnings of the dangers attending strike action are contained in the June issue of the official journal of the National Union of General and Municipal Workers. Mr. Tom Williamson, C.B.E., the union's general secretary, states that if the trade-union movement wants to commit suicide, there is no surer way of doing so than by "allowing the creeping paralysis of undisciplined industrial action to grow."

Never in its history, Mr. Williamson declares, had the trade-union movement been faced with a more serious situation than that which had arisen during the past few months. Irresponsible stoppages of work in certain sections of British industry had threatened the employment of thousands of other employees and had caused injury to the economic stability of the nation.

This, naturally, was creating an impression that the country's organised labour force was acting irresponsibly and becoming out of hand but, actually, there had never before been so many people at work and only a small proportion of that vast labour force, numbering more than 22 millions, had been directly involved in these serious stoppages of work.

Although only a comparatively small number of workers were involved in these stoppages, the effects could be extremely serious and there were suggestions in some quarters that remedial action, possibly legal action, might be taken. If anything was likely, in the long run, to prejudice the right to strike, it was the unjustified abuse of it, often in breach of contract, and in spite of provisions for negotiation and conciliation. These flagrant breaches of constitutions and rules brought the trade-union organisation into disrepute and warranted the strongest condemnation.

ENGINEERING EMPLOYEES' DEMANDS

A number of new demands on engineering employers for higher rates of pay and improvements in working conditions in the industry have been presented by the Confederation of Shipbuilding and Engineering Unions.

The men's proposals cover a good deal of ground and include requests for the payment of higher differentials for certain types of inspection work and for other employment entailing special responsibility, the payment of wages during sickness by firms which do not operate sickness-benefit schemes, and a national agreement that wages shall be paid during working hours.

The most important claim, financially, is a demand that double pay shall be granted for night-shift work and for all overtime, except that performed on Sundays, for which pay at three times the normal rate is asked. A further demand is that a general limit shall be set on the extent of overtime worked in the engineering industry.

Most of these demands were discussed at this year's annual meeting of the national committee of the Amalgamated Engineering Union, which was held at Blackpool and opened on April 25. Views were expressed then that the engineering industry was too dependent upon the regular working of overtime.

ROLLS-ROYCE STAFF SHARES PLAN

An announcement was made by Rolls-Royce Limited last Saturday that the company had plans in hand for re-shaping its profit-sharing scheme, which came into being shortly after the close of the 1914-18 war and has enjoyed a large measure of popularity. Proposals, it was stated, would be placed before an extraordinary general meeting of the company's stock-holders next month, to permit the firm's employees to hold one-tenth of its issued equity capital.

In his statement, issued with the annual accounts, Lord Hives, the company's chairman, mentions that the new arrangement would allow a substantial number of employees in responsible positions, or with long service, to participate in the capital of the company, which has been built up to its present position largely as a result of their efforts.

Under the existing scheme, employees' stock amounts to £145,000 and is held by less than 6 per cent. of the employees. The directors' plan for a larger and more flexible scheme is to create 1,200,000 shares of 10*s*. each, to be converted, when fully paid, into stock having the same rights as ordinary stock, in relation to dividends, voting and participation in new issues.